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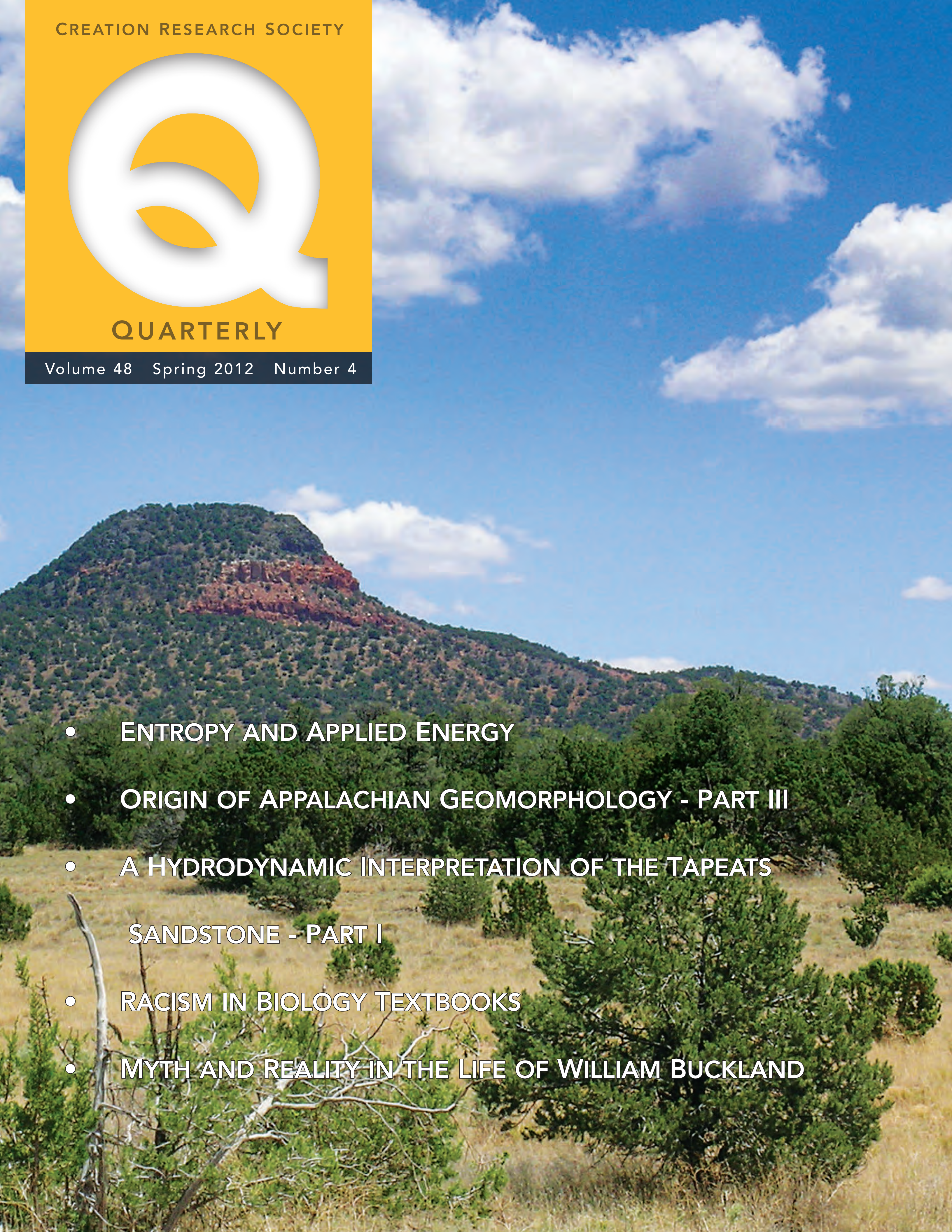

- ENTROPY AND APPLIED ENERGY
- ORIGIN OF APPALACHIAN GEOMORPHOLOGY - PART III
- A HYDRODYNAMIC INTERPRETATION OF THE TAPEATS SANDSTONE - PART I
- RACISM IN BIOLOGY TEXTBOOKS
- MYTH AND REALITY IN THE LIFE OF WILLIAM BUCKLAND

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Volume 48
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Articles

Entropy and Applied Energy ... 276
Charles Creager Jr.

Myth and Reality in the Life of William Buckland ... 280
John K. Reed

A Hydrodynamic Interpretation of the Tapeats Sandstone Part I: Basal Tapeats ... 288
W.R. Barnhart

Racism Taught in Biology Textbooks for Decades ... 312
Jerry Bergman

Origin of Appalachian Geomorphology Part III: Channelized Erosion Late in the Flood ... 329
Michael J. Oard

Departments

Notes from the Panorama of Science ... 352
Transgression/Regression in the Grand Canyon

Letter to the editor ... 355

Media Reviews ... 356

Instructions to Authors ... 363

Membership/Subscription Application and Renewal Form ... 365

Order Blank for Past Issues ... 366

Haec Credimus

For in six days the Lord made heaven and earth, the sea, and all that in them is, and rested on the seventh.—Exodus 20:11

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Entropy and Applied Energy

Charles Creager Jr.*

Abstract

Creationists have long used the second law of thermodynamics in arguments against evolution. The response has been that a system's entropy can decrease if energy is applied to that system and that the earth is such an open system. The problem is that there seems to be no general principle that shows how applied energy affects entropy. Even the most casual of observations shows that applying energy to a system can either increase or decrease entropy, depending on the nature of the application. This fact is best illustrated by the difference between construction work and a bomb. Despite this, there seems to be no general principle describing this difference. It turns out that statistical analysis of the problem provides this needed general principle. Herein it is shown that when energy is applied to a system, it tends to move the system's degree of randomness toward that of the applied energy. The result is that energy applied in an organized manner will decrease entropy, while energy applied in a random manner will increase entropy.

Introduction

The second law of thermodynamics has long been used by creationists to argue against evolution, particularly in the case of abiogenesis. This is because the second law shows that, left to itself, a system's entropy will always increase. However, it is known that the entropy of a system can be decreased by applying energy to that system, but there seems to be no general principle that addresses how applied energy will affect entropy. Even from the most casual of observations, it is clear that how energy is applied to a system determines how it affects the system's entropy. Energy can be applied in an organized manner, such as construction work, resulting in a decrease in the system's entropy; or it can be applied in a random manner, such as a bomb, resulting in an increase in the system's entropy. A statistical analysis of the problem provides this needed general principle.

Background

Statistically, entropy is logarithmically related to the randomness of a system (Bromberg, 1984), as shown in formula 1.

$$S = k \ln \Omega \tag{1}$$

where:
S = entropy

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k = Boltzmann constant = 1.380662×10^{-23} J K^{-1}
Ω = the number of equivalent micro states (possible arrangements) of a system.

Now the change in the entropy of a system is:

$$\Delta S = S_2 - S_1 \qquad (2)$$

Now, plugging formula 1 into formula 2 produces:

$$\Delta S = k \ln \Omega_2 - k \ln \Omega_1 = k \ln \Omega_2 / \Omega_1$$

Such that:

$$\Delta S = k \ln \Omega_2 / \Omega_1 \qquad (3)$$

Because of these relationships, the problem of applied energy is best dealt with statistically. Furthermore, any system consists of smaller parts with their own independent equivalent microstates resulting in formula 4.

$$\Omega_s = \Omega_1\, \Omega_2\, \Omega_3\, \Omega_4 \dots \Omega_N = \prod_{n=1}^{N} \Omega_n$$

$$\Omega_S = \prod_{n=1}^{N} \Omega_n \qquad (4)$$

where Ω_s is the total number of equivalent microstates, the product of the number Ω_n of microstates of each of the distinct smaller parts. Plugging formula 4 into formula 1 results in: $S_s = k \ln \Omega_s$, such that:

$$S_S = k\ \mathrm{h} \prod_{n=1}^{N} \Omega_n \qquad (5)$$

This forms the bases for analyzing what happens to the entropy of a system when energy is applied to it.

Analysis

The simplest possible system to analyze is one consisting of a single particle that is moved to a targeted location by the applied energy. The entropy of the applied energy (S_e) is related to the accuracy with which it can place the particle, such that Ω_e equals the number of locations (equivalent states) where the applied energy could actually place the particle. The result would be that entropy of the single particle system after the energy is applied would equal the entropy of the applied energy, such that: $S_s = S_e$.

In a complex system, the entropy of the applied energy would be the sum of the entropy of the energy applied to each component part of the system in accordance with formula 5, such that:

$$S_e = k\ \mathrm{h} \prod_{n=1}^{N} \Omega_{e} \qquad (6)$$

If the energy were applied to each component part of the system perfectly, then the entropy of the system after the energy is applied would be equal to the entropy of the applied energy, resulting in $S_s = S_e$. In the real world, this would not be the case, since some energy is lost.

However, at some level this process could be modeled such that some individual components of the system get energy applied to them while others do not. In such a model, each component would have one of two possible outcomes.

1. Component gets energy applied: $\Omega_{2n} = \Omega_{en}$.
2. Component does not get energy applied: $\Omega_{2n} = \Omega_{1n}$.

So when S_{s2} is calculated by formula 5, the total entropy of the system moves toward the entropy of the applied energy such that $\Delta S_{max} = S_e - S_s$. Applying formula 3 to this produces formula 7.

$$\Delta S_{max} = k \ln \Omega_e / \Omega_s \qquad (7)$$

In general, this indicates that applying energy to a system will move the entropy of that system. However, the actual change in entropy is a result of the amount of energy applied to the system. The amount of energy applied to a system is measured in the number of component parts of the system to which it is actually applied (σ), which is less than or equal to the total number of component parts of the system (N).

In systems with a variable Ω where energy is applied such that $\sigma << N$ and $\Omega_1 < \Omega_s < \Omega_2$, an anomaly can occur when $\Omega_1 < \Omega_e < \Omega_s$ or $\Omega_s < \Omega_e < \Omega_2$. A small increase in entropy can occur when $\Omega_e < \Omega_s$, or a small decrease in entropy can occur when $\Omega_s < \Omega_e$. In such cases, the change in Ω is limited to the range of Ω already within the system. This is because the anomalous change occurs only because the energy is affecting parts of the system with a $| \Omega_s - \Omega_n| > | \Omega_s - \Omega_e|$.

Discussion

The entropy change formula 7 shows the difference between construction work and a bomb. Construction work has a Ω_e smaller than the Ω_s of the raw material, while in a bomb a Ω_e is larger than the Ω_s of the raw material.

A good illustration is to consider what happens when a system is heated or cooled. It is known that heating a system produces a $\Delta S > 0$, while cooling a system produces a $\Delta S < 0$, and formula 7 shows why this occurs.

At the molecular level, heat energy is applied randomly such that $\Omega_e = \Omega_{s(Max)}$ for any system where $\Omega_s < \Omega_{s(Max)}$, and then heating the system produces a $\Delta S > 0$. This result is shown by $\Delta S_{max} = k \ln \Omega_e / \Omega_s = k \ln \Omega_{s(Max)} / \Omega_s$.

When a system is cooled, the electromagnetic forces between molecules are better able to guide the molecular motion such that the energy of these electromagnetic forces are applied to the system as a whole with $\Omega_e = \Omega_{s0}$ where $\Omega_{s0} = \Omega_s$ at absolute zero, so that for any system when $\Omega_s > \Omega_{s0}$, then cooling the system produces $\Delta S < 0$. This result is shown by $\Delta S_{max} = k \ln \Omega_e / \Omega_s = k \ln \Omega_{s0} / \Omega_s$.

This principle can be shown to apply to all systems, since the analysis is both system and path independent. The basic principle is that adding more randomness to a system makes it more random and adding more order to a system makes it more organized.

Prediction 1: The general application of energy to a system in a manner more random than that system will increase the entropy of that system.

Prediction 2: The general application of energy to a system in a manner less random than that system will decrease the entropy of that system.

It is already known that conservation and degeneration are observed in natural process, while the improvement processes needed for the evolutionary model are not observed (Williams, 1976). The present principle goes beyond the earlier concept, not only explaining this observation, but also providing the basic thermodynamic principles that set the process types apart. It shows that degeneration results from energy being applied to a system in a random manner, such as heat and radiation. Conservation of order and complexity can occur because it requires no net change. Also, such a conservation system already possesses the order and complexity it needs to maintain itself. A spontaneous improvement process would, by definition, require order and complexity to be produced where none exists. Thus, the present principle indicates that this is impossible, which explains why such processes are not observed.

Implications for the Origin of Life

This principle has profound implications for the idea of a naturalistic origin of life. The simplest possible living cell has a $\Omega_c = \Omega_s$. Energy can be applied to a nonliving system in three natural ways: molecular motion (heat), where $\Omega_e = \Omega_h$; radiation, where $\Omega_e = \Omega_r$; and molecular forces, where $\Omega_e = \Omega_m$.

Since both molecular motion and radiation interact with molecular systems like that of a living cell in essentially a totally random manner, then $\Omega_c << \Omega_h \approx \Omega_r$. Furthermore, while molecular forces do have a degree of order to them, it is far short of the order and complexity of the simplest possible living cell, so the result is that $\Omega_c << \Omega_m$.

This means that all of the naturally occurring forces that could be involved in the origin of life would drive any nonliving system, even those near the degree of order of a living cell, toward increased disorganization. As such, this would prevent any natural process from originating life. This is illustrated by the fact that when even the simplest cell dies, the cell's molecular structure breaks down and eventually disintegrates entirely.

Implications for Information Theory

Since information is a system that encodes and represents an abstract description of something else (Gitt, 1997, p. 85), then an information system would have an extremely low Ω_s. *Noise*, on the other hand, being defined as random changes in an information system, has a vary high Ω_e, such that $\Omega_s << \Omega_e$. The result is that noise always destroys and distorts information and never creates it, as is actually observed in information systems.

Implications for DNA

Deoxyribonucleic Acid (DNA) is the information storage medium for living things (Gitt, 1997, p. 90). Like any information system, it has an extremely low $\Omega_{DNA} = \Omega_s$. Likewise, mutations apply energy to DNA such that $\Omega_m = \Omega_e$. This application of energy has an extremely high Ω_m so that $\Omega_{DNA} << \Omega_m$. This can only result in the information in the DNA being damaged or destroyed, and thus these entropy change equations reinforce the observation that genetic mutations are very harmful (Sanford, 2005).

These results mean the total collapse of all naturalistic methods for producing information in the DNA of living things. Evolutionists often invoke natural selection as a solution. To qualify as an adequate solution, however, natural selection would have to apply energy to DNA with an $\Omega_{ns} = \Omega_e < \Omega_{DNA}$.

As it turns out, natural selection is incapable of meeting the above requirement. Natural selection does not have a well-defined objective, which would be needed to have $\Omega_{ns} < \Omega_{DNA}$ since each DNA instruction has a well-defined meaning within the cell. Furthermore, natural selection does not apply energy to the DNA under consideration. In fact, it does not act directly on DNA; it only reacts to the traits that information of existing DNA produces. As a result there is no Ω_{ns} to be applied to the DNA, meaning that natural selection is totally incapable of increasing genetic information.

Implications for Living Systems

It has been previously shown that living systems are generally conservation systems in that the increase of their entropy over time is slower than that of nonliving systems. This applies not only to individual organisms, but to entire created kinds as well (Williams, 1971). The present principle not only applies to both living and nonliving systems, but also allows the earlier concept to be more clearly explained. The reason living systems are generally conservative is that they apply energy to maintain themselves against degeneration such that $\Omega_e \approx \Omega_s$. However, they increase their entropy because Ω_e is always a little greater than Ω_s. As such, living systems will always increase their entropy over time, even if at a slower rate than a nonliving system.

Summary

It has been shown herein that when energy is applied to a system, the degree of randomness of the system moves toward the degree of randomness of the applied energy. When energy is applied in a manner more random than the system to which it is applied, the system's entropy increases. When energy is applied in a manner less random than the system to which it is applied, the system's entropy decreases. This represents a general concept of how applied energy affects a system's entropy in any application of energy to any system. Furthermore, this provides a solid answer to the argument that a naturalistic origin of life is consistent with the laws of thermodynamics because the earth is an open system. The argument fails because that energy is applied in a manner far more random than the high degree of organized complexity of even the simplest living cell.

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Myth and Reality in the Life of William Buckland

John K. Reed*

Abstract

William Buckland is the prototypical "Christian-finds-science" straw man of secular propaganda. He appears as a pre-incarnation of Henry Morris, wrestles with geological facts that contradict the Flood, sees the light, and finally repudiates the Flood—just another tragic zealot finding true enlightenment through "science." The false moral is clear; Christians who open their eyes convert to secularism. Like many other secular myths, that view of Buckland is absurd. The real Buckland was an elite geologist with a brilliant career, receiving accolades from society and peers. The real tragedy was not an imaginary psychological conflict between science and religion, but the long road of compromise that marked his career, and the real moral is the necessity of fidelity to Scripture.

Introduction

Recent scholarship in the history of geology has unveiled a new layer of deceit by secularism. Around the core errors of that worldview is wrapped a protective wall of mythology depicting the history of geology as the triumph of science over superstition.

> In the introduction to *Bursting the Limits of Time* I mentioned briefly why this kind of historiography has long been abandoned by historians, although it remains popular in the modern media, and above all in the rhetoric of those self-appointed spokespersons for "Science" who are, in effect, atheistic fundamentalists. (Rudwick, 2008, p. 5)

Although these myths are still propagated—despite the demonstration of a more complex reality (Gould, 1987; Laudan, 1987; Mortenson, 2004, 2006; Rudwick, 1997, 2005, 2008)—truth is seeping through. We now know that geology did not originate with James Hutton, but decades earlier with continental naturalists—men who scoffed at his deistic geotheory. We know that Lyell was no brave empiricist, overthrowing organized religion. We know that Georges Cuvier was not a Christian apologist for the Flood.

Another key myth has been built around another key character in this secularist farce—William Buckland. For many decades, he was a significant propaganda tool—the troubled Christian who gradually saw the light of science, cast off superstition, and embraced secular geohistory. He remains a symbol of the supposed struggle between the darkness of religion and the light of secularism. For example, Laudan (1987, p. 170) categorized Buckland as a "biblical" geologist:

> Of course, some biblical geologists lingered on, particularly in Britain. But the more reputable of these, such as William Buckland, laid the onus of their reconstruction on the rocks, not on the Bible.

Extreme caricatures of Buckland elicited Rudwick's (2008, p. 426) condemnation:

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> The artist captured his [Buckland's] deeply serious character, which belies his later and unwarranted dismissal as a mere buffoon.

So at best, he was a "reputable" biblical geologist, and at worst, a buffoon. This popular depiction of Buckland is doubly deceitful because (1) Buckland was not a proponent of biblical history, and (2) Buckland readily compromised biblical truth for current theories of geology. He was not simply a "more reputable" edition of the scriptural geologists, who were young-earth creationists (Mortenson, 2004); rather Buckland opposed them, helped by compromising clerics such as William Conybeare and Adam Sedgwick. Needless to say, the secular naturalists of the day were unanimous in their condemnation of the scriptural geologists. Given the contemporary appeal of compromise, Buckland's *real* life and errors are instructive examples of how easily entangled Christians can become in secularism once they relinquish the authority of Scripture. Buckland's career is not a morality tale rebuking creationists, but one for Christians who think they can integrate secular prehistory into the Bible's teaching.

Figure 1. William Buckland was a pioneer of English geology. From nndb.com (March 2011).

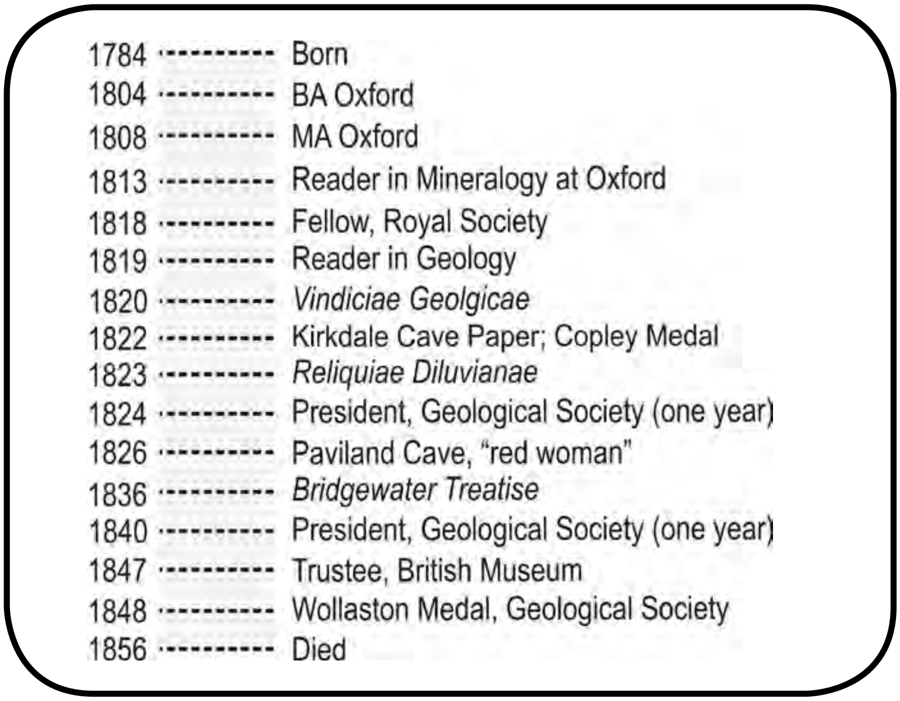
Summary of Buckland's Life

William Buckland (Figure 1) was a dominant figure in British science in the early nineteenth century. He was an accomplished and competent field geologist and honored as such throughout his career (Figure 2). Born in 1784 in Devon, Buckland entered Oxford shortly after the turn of the century, earning BA (1804) and MA (1808) degrees. He was ordained into the Anglican clergy in 1809, the same year he was made a fellow of Corpus Christi College at Oxford.

Like many clerics of the time, his interest was in science and natural history. He became a Reader in Mineralogy in 1813 and was appointed a Fellow in the Royal Society in 1818, having already achieved prominence in the Geological Society of London, founded in 1807. During the 1820s he achieved international prominence built on productive work. In 1820, his *Vindiciae Geologicae* established him in the top tier of geologists in England. He attained international prominence with his 1822 paper that reconstructed the natural history of Kirkdale Cave in Yorkshire—a paper that earned him the Royal Society's Copley medal. "Buckland's fame was rising rapidly, and not only in Britain" (Rudwick, 2008, p. 80).

He could accurately be described as a disciple of Georges Cuvier (the French paleontologist and comparative anatomist), although Buckland probably had a closer affinity to orthodox Christianity than his French mentor. Following Cuvier, Buckland took a catastrophist view of history. In 1823, he summarized his ideas about a geological "deluge" in his *Reliquiae Diluvianae*. The following year, he presented a paper on a fossil dinosaur, which he called the "Megalosaur," and was elected president of the Geological Society, a position he would again hold in 1840.

Continuing his work on caves in the 1820s, Buckland's next big find was at Paviland cave in Wales, which included a human fossil, called the "red woman." In 1829, he identified fossil feces, coin-



1784 ---------- Born
1804 ---------- BA Oxford
1808 ---------- MA Oxford
1813 ---------- Reader in Mineralogy at Oxford
1818 ---------- Fellow, Royal Society
1819 ---------- Reader in Geology
1820 ---------- *Vindiciae Geolgicae*
1822 ---------- Kirkdale Cave Paper; Copley Medal
1823 ---------- *Reliquiae Diluvianae*
1824 ---------- President, Geological Society (one year)
1826 ---------- Paviland Cave, "red woman"
1836 ---------- *Bridgewater Treatise*
1840 ---------- President, Geological Society (one year)
1847 ---------- Trustee, British Museum
1848 ---------- Wollaston Medal, Geological Society
1856 ---------- Died

Figure 2. Timeline of William Buckland's life and career with famous publications in italics. Note the honors and awards indicating high professional regard by his society and peers until his final illness.

ing the term “coprolite.” In 1836, he published one of the eight Bridgewater Treatises on the relationship between geology and natural theology. By then, he had reached the height of his career and its accompanying international prominence. During the 1840s he was appointed to the Deanery of Westminster and Islip, appointed a trustee of the British Museum, and awarded the Wollaston Medal by the Geological Society. In 1849, he contracted a tubercular infection that led to his death in 1856. In short, Buckland was one of the most prominent practitioners of the new science of geology, with a reputation across Europe as a competent and successful savant, despite the critics of his “diluvial” theory.

Like Jean Andre de Luc in the previous century, Buckland discovered quickly that defending even a watered-down version of the Genesis Flood brought many opponents. Rudwick cannot fathom why a scientist of Buckland’s stature would attempt to integrate biblical belief with science. Note how he implies that Buckland’s diluvial research was a separate, inferior project to his “regular” scientific research.

> All this work established Buckland as a competent field geologist in the mainstream of the new research; his work on the Stonesfield Megalosaur fitted into this stratigraphical framework, while extending it in a zoological direction that depended crucially on Cuvier’s expertise. *On the other hand*, Buckland’s famous inaugural lecture at Oxford [1819], focusing on the problems of the Superficial deposits and interpreting them as the physical traces of the “geological deluge” that he identified as the biblical Flood, represented a *distinctly different line of research*, carried on in parallel with his other work and *only loosely linked* to it. (Rudwick, 2008, p. 73, emphasis added)

However, it is clear from Buckland’s work and writings that a universal aqueous catastrophe was an integral part of natural history, just as gradualism was for Lyell. The key to understanding Buckland is not the hackneyed “faith versus science” mantra of atheists but his conception of the “deluge” in the context of earth history and the rock record. However, his idea of a geological deluge was not the Genesis Flood, and secular critics who link him to modern creationists only reveal their ignorance.

Buckland’s Geological Deluge: Not Noah’s Flood

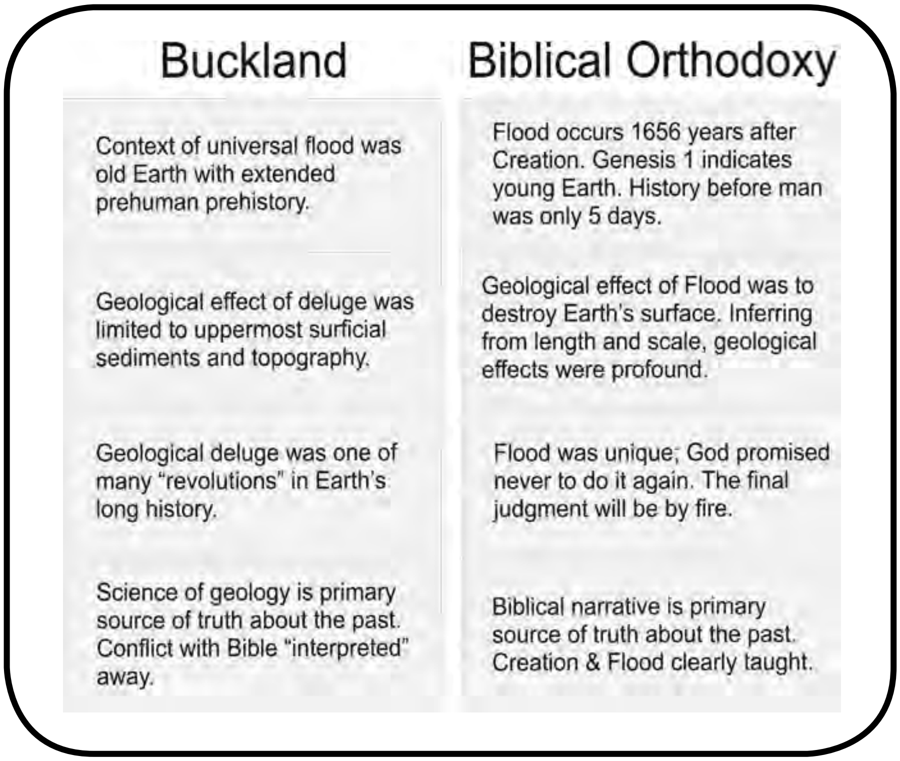
How did Buckland’s geological “deluge” differ from the Genesis Flood? Buckland’s “deluge” view differed in four significant ways from Genesis: (1) Its primary source of truth was geology, not Scripture, (2) it was an event on an old earth, (3) it was limited in its effects to the surficial deposits of the rock record and topography, and (4) it was one of many catastrophes, the rest of which predated Adam (Figure 3).

Buckland was no young-earth geologist.

> For Buckland, as for de Luc before him, the religious value of the biblical writings was dependent on their reliability *as history*. Like many earlier savants, he had no hesitation in interpreting the Creation story in Genesis in a non-literal way, allowing for a vast prehuman antiquity of the earth. (Rudwick, 2008, p. 82)

His “geological deluge” was limited to the superficial deposits, as illustrated by his classification of cave-fill fossils as “antediluvian.

> Strictly speaking, the fossil bones of Kirkdale and other caves were not themselves “relics of the deluge”, but traces of an earlier or “antediluvian” period that the deluge had brought to an end. (Rudwick, 2008, p. 82)



Buckland	Biblical Orthodoxy
Context of universal flood was old Earth with extended prehuman prehistory.	Flood occurs 1656 years after Creation. Genesis 1 indicates young Earth. History before man was only 5 days.
Geological effect of deluge was limited to uppermost surficial sediments and topography.	Geological effect of Flood was to destroy Earth's surface. Inferring from length and scale, geological effects were profound.
Geological deluge was one of many “revolutions” in Earth's long history.	Flood was unique; God promised never to do it again. The final judgment will be by fire.
Science of geology is primary source of truth about the past. Conflict with Bible “interpreted” away.	Biblical narrative is primary source of truth about the past. Creation & Flood clearly taught.

Figure 3. Buckland’s geological deluge only superficially resembled the Genesis Flood because his primary source of information was geology, not Scripture. Other errors flowed from that initial mistake.

Finally, the “deluge” was only the

last of many "revolutions" in earth history.

> All this research had reinforced his [Buckland's] Cuvierian argument that a drastic and widespread diluvial event in the geologically recent past had been the last of the earth's occasional "revolutions." (Rudwick, 2008, p. 75)

In contrast, Genesis eliminates prehistory with its first three words. The "human age" began five days after Creation. The real Flood was a hydraulic catastrophe that destroyed earth's surface, and Buckland vastly underestimated its potential for geological work. Its deposits include most of the rock record, not superficial, unconsolidated sediment. Finally, it was a unique event, never before seen and never again to be repeated.

Buckland also erred in following men instead of the Bible. He was especially influenced by Cuvier—arguably the most prominent naturalist in early nineteenth-century continental Europe (Rudwick, 1997). Buckland emulated Cuvier's methods, identified with his ideas, and sought his aid with fossil discoveries in England. Both believed in an old earth. Both believed in an abrupt transition separating the "ancient world" from the "modern world" and that the transition could be linked to the biblical story of the Flood, though neither accepted the narrative as a literal and accurate account. To them it was simply another ancient legend, a remnant in human memory of an ancient catastrophe. Buckland's position was not far from that of a modern neocatastrophist who happens to be a Christian.

> Buckland's reconstruction of a vanished ecosystem in recent geohistory … was seen at the time as a sensational foretaste of what the great Parisian naturalist Georges Cuvier had eloquently set out, just ten years earlier, as a worthy and attainable goal for the new science of geology. "Would it not be glorious", Cuvier had asked rhetorically, for geologists to "burst the limits of time", just as astronomers had "burst the limits of space"? (Rudwick, 2005, p. 1)

Buckland's advocacy of Noah's Flood was quite different from that of the scriptural geologists of his day or modern creationists. Instead, if alive now, he would likely prefer the company of compromising Christians like Hugh Ross and Davis Young. But Buckland put geology's authority before that of Scripture; his unquestioning acceptance of secular prehistory before the "deluge" was seen in his conventional view of stratigraphy (cf. Mortenson, 2006).

> Buckland's remarkably effective correlations—using fossils in the Smithian manner [William Smith's use of index fossils to provide relative dates of strata] that was already becoming routine—contributed to the widespread sense that the English sequence was indeed worth treating as a standard of reference. … Conybeare and his friend Buckland helped ensure that the British sequence, which was already well known and seemed to be exceptionally complete, came to be treated as a useful reference standard for the whole of Europe and even, more tentatively, for the rest of the world. (Rudwick, 2008, pp. 41, 45–46)

Of course, the only way to have known that the British sequence was both complete and was an exemplar of global stratigraphy was to first assume a global geologic column (Reed, 2008).

Buckland's limited "geological deluge" is seen in his acclaimed reconstruction of a paleoenvironment from fossils found in the Kirkdale cave (Buckland, 1822). Rudwick summarizes:

> Buckland's "diluvial" research was hugely enhanced by the chance discovery of Kirkdale Cave in Yorkshire, with its rich haul of fossil bones. These were … confirmed by Cuvier in Paris; but this indoor museum work on comparative anatomy was complemented crucially by Buckland's own outdoor fieldwork on the geological context of the cave itself. Combining the two sources of evidence, he constructed the sensational "hyaena story" that he presented to the Royal Society in 1822, and for which he received the Copley medal. … He interpreted the cave as a former den of large extinct hyenas, scavenging a varied diet of animals ranging in size from mammoths to water rats and including both carnivores and herbivores. … Buckland argued that they demonstrated that the den had been occupied at a geologically very recent period, and that the hyenas had been wiped out no more than a few millennia ago, a time compatible with any of the varied dates … traditionally computed on textual grounds for the biblical Flood. … Buckland's "hyaena story" based on Kirkdale made him not only well known in savant circles in London but also more prominent than ever in his university. (Rudwick, 2008, pp. 73, 75)

Buckland's discovery was captured by a cartoon drawn by fellow Anglican cleric and geologist, William Conybeare, in 1821, shown in Figure 4.

Investigation of this geological (but not necessarily biblical) "deluge" was Buckland's primary interest in the 1820s, reinforced by subsequent work.

> Buckland's interpretation of Kirkdale Cave … was buttressed by several other lines of research. In earlier fieldwork … he had used telltale pebbles to track a "diluvial current" that … had swept from the Midlands plain up over a watershed and down into the Thames valley … in a way that was quite inexplicable in terms of the ordinary action of the present rivers. Likewise, he had interpreted the topography on the south coast as evidence that the valleys had been scoured out by a rapid current. … All this research had reinforced his

Figure 4. Cartoon of Buckland's "discovery" of an antediluvian hyena den in Kirkdale cave near Oxford. Drawn by William Conybeare in 1821. The candle in Buckland's hand represents the light of science penetrating the past. From historyofgeology.blogspot.com (April 2011).

> Cuvierian argument that a drastic and widespread diluvial event in the geologically recent past had been the last of the earth's occasional "revolutions." (Rudwick, 2008, p. 75)

In 1823, Buckland published his *Reliquiae Diluvianae*. In 1826, another cave discovery at Paviland provided more fodder for the "deluge" interpretation. The cave even included a human skeleton, but Buckland's reaction illustrates the primacy of secular geohistory in his thinking.

> By far the most important discovery at Paviland was apparently made by Buckland himself. In addition to the usual "antediluvial" mammal bones, an incomplete human skeleton was found lying close to the surface of the deposit on the floor of the cave. Since Buckland identified the "geological deluge" as the biblical Flood, it might have been anticipated that he would be delighted … to find a human victim of that event and hence to have the date of the geological deluge confirmed as falling within the human period. But Buckland took his cue from Cuvier, who with good reason had been highly skeptical about all such alleged human fossils. (Rudwick, 2008, p. 77)

In other words, Buckland accepted the views of secular naturalists over the Bible. He was happy if the Bible supported his beloved geology, but the geology clearly took precedence. This mistake opened the door for two other errors: (1) the "geological deluge" only produced superficial deposits, and (2) human fossils could not be antediluvian, even though it could be argued that they had the same cause as the "antediluvian" mammal fossils in the same cave fill. Ironically, in the case of the "red woman" fossil, instead of "taking his cue" from the field evidence, he took it from his mentor, Cuvier. Then he found a convenient way to attempt to integrate his "scientific" conclusion with Genesis.

> Buckland had good reason to stay on the side of caution and Cuvier, and to conclude that there was still no evidence that early humans had spread as far as Britain by the time that the deluge overwhelmed the country. For him, as for Cuvier, this did not weaken the case for identifying the geological deluge as the event recorded in Genesis. Both savants assumed that human life had been far more restricted geographically before the deluge than it became with the rise of civilizations after the event. It had long been conventional to locate the likely area of origin of the human species somewhere in Asia. (Rudwick, 2008, p. 79)

British and continental diluvialism abandoned the Scripture's description of the Flood for imaginary theories such as "mega-tsunamis." Buckland embraced these secular theorists:

> He particularly recommended those who doubted his interpretation to study the work of Hutton's friend Sir James Hall (1761–1832), who had reconstructed just such violent currents in the Edinburgh region and had explained them explicitly by analogy with modern tsunamis. Hall's research showed, as Buckland put it, that "the surface of the earth owes its last form not to the gradual action of existing causes, but to the excavating force of a suddenly overwhelming and transient mass of waster." (Rudwick, 2008, p. 80)

But even a "secular" version of the Flood was spurned by most of Buckland's contemporaries. They chose a clear break with Christianity, allowing no possibility of a link between the Bible and geology. That is why the "scriptural geologists" were the object of scorn of both Buckland and his gradualist opponents.

> In the *Edinburgh Review* … Fitton … conceded that the new work [of Buckland] was strictly scientific, and quite distinct from the increasingly popular genre of "*scriptural geology*." But since he and other geologists regarded the latter as scientifically worthless, he regretted that Buckland had not kept geology and Genesis more clearly separate. (Rudwick, 2008, p. 84)

Fitton, therefore, rejected any possibility of truth from the Bible. Why else would he want to separate the "purity" of science from the "contamination" of Genesis? It is amazing that this proto-positivism so easily deluded otherwise intelligent men.

There is little doubt that Buckland found a more ready audience among the educated public in England than on the continent. England was one of the last nations in Western Europe to abandon Christian continued orthodoxy. The fight over the Bible and history had already been lost on the continent:

> Buckland's analysis of … caves was designed, then, to support an underlying historical claim: that the catastrophic "geological deluge" was so recent in date that it could be identified as the biblical Flood. This claim to have particular resonance in the British context, owing to its perceived implications for the reliability of the biblical documents as a whole, and hence for the wider issues of the relation between church and state. On the Continent, where the political situation was quite different, the British preoccupation with issues of "geology and Genesis" left many savants amused, or at least bemused. (Rudwick, 2008, pp. 82–83)

So the continental savants were able to laugh off the Flood. In England, the possibility of defending Scripture from secular assaults drove Buckland's British critics to anger, instead. As seen today, the Genesis Flood triggered irrational reactions from supposedly "open-minded" empiricists. "Buckland's critics balked, however, at the second component of his diluvial theory … that the geological deluge was recent enough to be identified as none other than Noah's Flood (Rudwick, 2005, p. 83). This national differential in spiritual decline explains the differences between Buckland and Cuvier.

> Buckland … focused exclusively on the ancient textual testimony of Genesis. This served Buckland's purpose of giving the science of geology legitimacy and respectability in his local academic environment, while also bolstering the role of religious authority generally; but conversely it laid him open to criticism by those who had their own agendas for undermining that authority. (Rudwick, 2005, p. 83)

This religious animosity of the English deists and secularists explains the deep dislike of Buckland's work by Fleming, Scrope, Lyell, and others. Secular historians generally have little interest in church history, and so they fail to associate the rise of secular natural history with a period of spiritual and theological weakness in the church. Instead, they follow the paradigm of "the rise of geology" and the mantra of "science versus religion." In doing so, they miss an important factor in the events of the early 1800s.

Secular historians have propagated the myth that the ascent of Christianity in Europe led to the "Dark Ages," which were relieved only by the rebirth of pagan classicalism in the Renaissance and Enlightenment. Stark (2003), among many others, demonstrates the inaccuracy of this view, noting that technological and social progress in the "Dark Ages" exceeded that of Rome. Glover (1984) also notes the Christianization was not an immediate phenomenon; Europe was not predominantly Christian until the late "Dark Ages." Social reform exploded during the Reformation, and theological renewal occupied people of all social strata, though it was led by academics like Luther and Calvin. This stands in stark contrast to later Christian renewals.

The Wesleyan revivals of the 1700s—fighting against the rising tide of deism and secularism—were primarily a phenomenon of the lower and middle classes in England and America, leaving the "high" Anglican Church much less affected. From an academic viewpoint, the "intellectuals" of the day were, unlike their Reformation forefathers, given over to heresy. Orthodox Christianity had lost its appeal to the British intellectual class. It is no surprise, then, that the new secular earth and life sciences were dominated by men holding the post-Christian worldview of naturalism.

That trend was manifested in John Fleming.

> Another well informed critic … took issue with Buckland's assumption … that only a sudden and drastic physical event could have wiped out a whole fauna of well-adapted animals. John Fleming (1785–1857) was a highly competent naturalist who had been closely associated with Jameson in Edinburgh before becoming a Church of Scotland minister in the rural parish of Flisk in Fifeshire. … In response to Buckland's *Reliquiae*, Fleming concluded his article with a vehement attack on the English geologist's "indiscreet union of Geology and Revelation", which in his opinion deserved Francis Bacon's classic censure for having led to "*Philosophia phantastica, Religio haeretica*". The criticism showed that not all ordained ministers of established churches approved of Buckland's deployment of Genesis in scientific debate. (Rudwick, 2005, p. 84, 85)

Instead, Fleming's criticism showed the extent to which heresy had spread. Rudwick misinterpreted the acerbic response of the heretical Fleming as representing a diversity of legitimate opinion within the clergy. In doing so, he failed to take into account the classic Reformation distinction between the visible and invisible church; the former being a mixture of believers and unbelievers, and, as Jesus noted in Matthew 7:15 (KJV), "false prophets, which come to you in sheep's clothing, but inwardly they are ravening wolves." Had Rudwick simply read the confessional documents of the Church of Scotland at that time, he would have clearly seen Fleming as one of the "wolves."

Compromise Leads to Compromise

William Buckland occupied a unique position at the end of his career. He was a highly respected member of England's scientific elite, yet his main ideas had been cast aside in favor of Lyell's almost static gradualism. Secular propagandists have long portrayed Buckland's "capitulation" as the epitome of the victory of science over religion, contrasting Buckland's strong diluvialism in the early 1820s to his later retreat in his 1836 Bridgewater Treatise. But the reality is that Buckland, who had already compromised on the authority of science, an old earth, and a flood of little geological consequence, simply moved a little closer to the logical conclusion of that position.

> This gradual withdrawal—by geologists—from any simple correlation between geological deluge and biblical Flood culminated, in effect, in Buckland's concession that his own earlier claim that they were identical now needed dramatic revision in the light of more recent research. A footnote in his Bridgewater Treatise showed the wider public that he, like Sedgwick before him, had now abandoned the equation. He described the event that had entombed the diluvial fossils as "the last of many geological revolutions that have been produced by violent irruptions of water, rather than the comparatively tranquil inundation described in the Inspired Narrative [in Genesis]." (Rudwick, 2008, p. 427)

Despite having abandoned the historical reality of the Genesis Flood, Buckland, like many modern compromisers, continued futilely to try to square the circle. It is no surprise that he came to advocate a local flood based on a restricted area of human population.

> Buckland's revision severed the last link between his own "diluvium" and the *biblical* "deluge" or Flood. The historical reality of the latter could still be maintained, however, simply by adopting the interpretation that biblical scholars in any case preferred … restricting the universality of the Flood to whatever limited area the human species had occupied at that time. (Rudwick, 2008, p. 427)

This is precisely the excuse used by Glenn Morton (1999) in his attempt to integrate an old earth with the Bible. The numerous problems with this position have been documented in Sarfati (2004), for example, as they were by Whitcomb and Morris (1961). Buckland's path has been followed closely by contemporary compromising Christians. All rest their case on the geologic timescale and the secular stratigraphic interpretation of the rock record. Buckland was in the vanguard of this movement.

> Buckland's main argument, no less than Lyell's, depended necessarily on a factual foundation of stratigraphy. Unless the sequence of formations was reliably established, no inferences about time and geohistory could be regarded as secure. (Rudwick, 2008, p. 428)

So the real story of William Buckland is not that of the conversion of a "biblical geologist" to secular truth but that of small compromise leading to larger compromise on the path to secularism. Buckland first compromised the authority of Scripture by making geology the final arbiter of historical truth. After that fateful step, succeeding compromises multiplied. The first was the acceptance of a prehuman prehistory, despite man's creation in the earth's first week. Facing an old earth and a prehistory open only to science, Buckland had to find a way to save the Flood. Cuvier had pointed the way by drawing a sharp distinction between the ancient world and the modern world based on his paleontological research in the Paris Basin. His geological "revolution" could be linked to Genesis in an offhand manner, but as time showed, both Cuvier and Buckland stood ready to jettison the Bible in favor of secular natural history.

This untenable position forced Buckland to limit the geological extent of the Flood. Since the bulk of the rock record was a relic of the ancient world, he was forced to confine the Flood to the uppermost surficial sediments, like cave fill, complete with their "antediluvian" fossils. Had he used his clerical training to exegete Genesis 6–8 carefully, he would have realized the impossibility of such a flood being compatible with the Genesis narrative. So one step at a time, the Flood was divorced from the rock record; Buckland's "diluvium" was later largely attributed to glaciation. Secularists crowed at the dismissal of the Flood, not realizing that the falsification of Buckland's position was as good an argument for the scriptural geologists' position as it was for the uniformitarian one. And of course, the real lessons of Buckland's work could be applied to today's Christians who claim fidelity to the Bible while ignoring the detailed and clear message of the text with regard to the extent and impact of the Flood.

Conclusion

Enlightenment secularists used the "religion versus science" argument with great success for many years. Today, most recognize the argument as propaganda, but in the heady days of the 1800s, it seemed like nothing more than common sense, and Enlightenment propagandists used it to distort the history of geology. William Buckland is a case in point. From being a member of Britain's geological elite, he quickly descended, as Rudwick noted, to the status of a "buffoon." That Enlightenment distortion fit well with the story of the overthrow of Genesis by geology but has little correspondence to reality. Instead, Buckland's compromises conceded doctrine after doctrine to secularism, making him an odd choice for the secular straw man.

Buckland was no "biblical geologist," struggling against science. Rather, he was a perfect example of how compromise leads to more compromise and finally to ridicule and defeat for Christian orthodoxy. The real message of Buckland's career, and one sadly ignored by many Christian geologists today, is that there is no way to square the circle between secular natural history and the clear teachings of Scripture. If a man of Buckland's intelligence and accomplishments failed, then it seems unlikely that his intellectual children will succeed.

Creationism is ridiculed by secular scientists and compromising Christians. In that regard, little has changed since the early nineteenth century. Secular naturalists and compromisers like Buckland both reserved their true animosity for the scriptural geologists. It is worth wondering, if Christianity's teachings on the afterlife and judgment are true, which group is standing in God's favor—Buckland, Sedgwick, Conybeare, and the other clerical compromisers or the scriptural geologists? Although the former have by now learned the error of their ways, their modern counterparts have not.

> The many [geologists] who were also religious believers saw no conflict between geology and their understanding of the Creation stories of Genesis; they had long since learned that it was a *religious* mistake to treat biblical texts as if they were scientific sources, because an inappropriate literalism deflected attention away from religious meaning. It is true that some of these geologists, particularly in England, had to confront vocal critics—the self-styled "scriptural" writers—who relentlessly pursued a literalist line on matters of "geology and Genesis." But this, like the modern and peculiarly American phenomenon of creationism and other forms of religious fundamentalism, was a contingent feature of a particular time, place, and, above all, social location. (Rudwick, 2005, p. 5)

A more accurate assessment of today's compromisers is found in Heard (1985):

Years of error leave a trail;
And still we walk it, meaning well. …

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A Hydrodynamic Interpretation of the Tapeats Sandstone

Part I: Basal Tapeats

W.R. Barnhart*

Abstract

The Tapeats Sandstone is the lowest Cambrian layer in the Grand Canyon in Arizona. It has been interpreted as beach, estuarine, and shallow marine coarse sand deposits, representing the initial stages of a slow transgression over a highly weathered and eroded, pre-vegetated epicratonic surface. In the basal Tapeats, two distinct bedforms occur: (1) hyperconcentrated laminar bedforms deposited by high-velocity hyperconcentrated currents and (2) sandy debris flows in high-density turbulent flow. The high-velocity hyperconcentrated currents predominated, but were occasionally interrupted or overlaid by cascades of breccia that initiated short-lived, high-density turbulent flow. Both reflect extremely rapid deposition rather than tidal reworking on a passive margin. Rheologically plastic flows are distinct from fluidal flows. The structure of high-density turbidity currents and hyperconcentrated flood flows are discussed, showing how the hyperconcentrated laminar bedforms and sandy debris flows could have been produced. Hydrological interpretation indicates that bedforms were produced by very rapid deposition in continuous currents over an extremely large area without regard for minor paleotopography, suggesting the rapid transgression of the Tapeats Sandstone in a massive flooding event.

Introduction

The Tapeats Sandstone is the lowest formation of the Paleozoic Tonto Group at Grand Canyon. Named for exposures along Tapeats Creek by Noble in 1914, this sandstone formation and the overlying Bright Angel Shale and Mauve Limestone (Figure 1) have been classified as Cambrian since the classic work of Walcott (1890).

Cambrian deposits in the Grand Canyon and throughout the Rocky Mountains long have been cited as representing a classic transgressive sequence of sandstone, mudstone, and limestone that accumulated on the slowly subsiding Cordilleran miogeocline and adjacent craton. Shoreline migration for the most part was eastward, resulting in deposition

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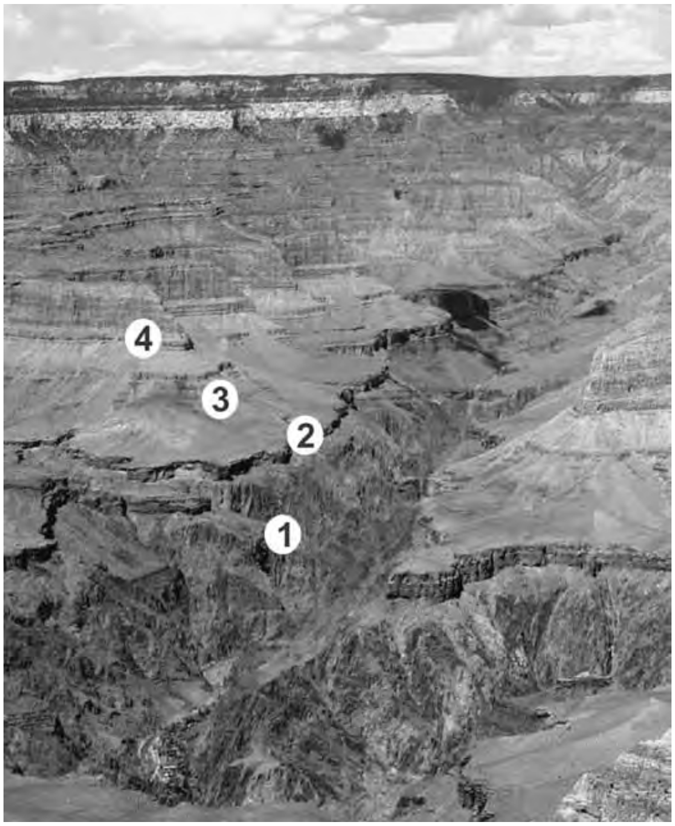


Figure 1. Overview of Grand Canyon showing Cambrian strata in context. 1 = Vishnu Schist; 2 = Tapeats Sandstone; 3 = Bright Angel Shale; 4 = Mauve Limestone. From http://thevibe.socialvibe.com/wp-content/uploads/2009/01/arizona-grand-canyon-vista.jpg (accessed December 2010)

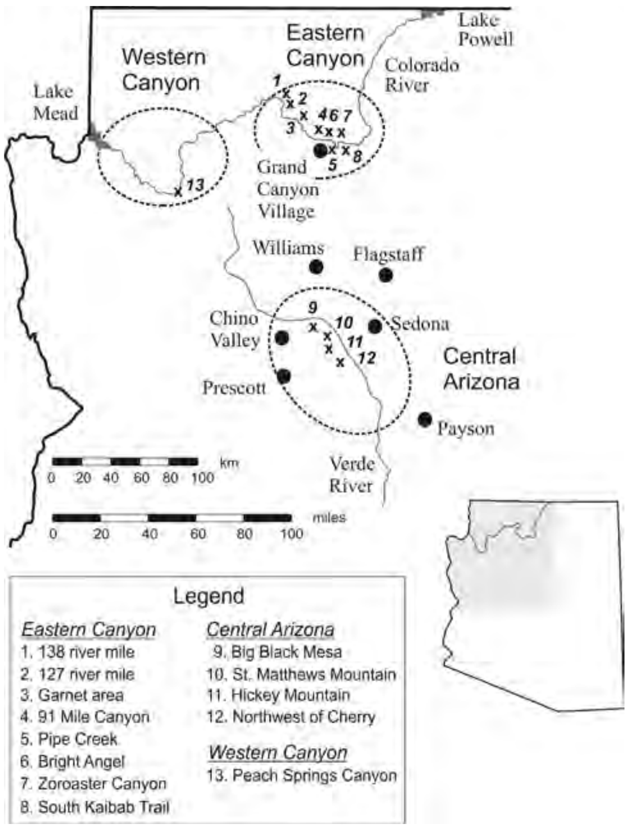


Figure 2. Areas of exposure of Tapeats Sandstone in Arizona, USA. Three major locations include: western canyon, eastern canyon, and central Arizona. Major monadnock locations are labeled showing the north-south alignment.

> of coarse clastics in shallow water areas to the east and finer clastics and carbonates in more offshore areas to the west (Middleton and Elliott, 2003, p. 90).

In the eastern Grand Canyon and central Arizona region (Figure 2) the Tapeats is interrupted by numerous monadnocks—irregular hills or highs in the Precambrian surface, some extending into the Bright Angel Shale. These are often associated with deposits of loose breccia, apparently eroded from the monadnocks, which cover the bases and sides of the hills, reaching 50 ft (15.3 m) in thickness (Middleton and Elliott, 2003). These monadnocks were interpreted as paleohills by McKee (1945) and many others, who imagined the Tapeats depositional environment as a broad beach gradually covering the ancient topography, migrating over rising land to the northeast (Hereford, 1977; Rose, 2006).

Within that general uniformitarian concept, various ideas have been advanced for deposition in estuaries, on beaches, and in shallow marine offshore environments, resulting in a variety of facies models for the Tapeats. McKee (1945) viewed it as a subtidal deposit with sediment arriving from the northeast to be reworked by tidal action in water less than 50–60 ft (15.3–18.3 m) deep. Wanless (1973), based on the occurrence of "fenestrated fabrics and dessication cracks" (Middleton and Elliott, 2003, p. 95) in the Mauve Limestone, suggested at least part of the Tonto Group was deposited subaerially. Hereford (1977, p. 201, 203, 209, brackets added), working Tapeats outcrops in central Arizona (Figure 2), used "more than 800 orientation measurements" to conclude that "the average direction of sediment transport was west-southwest" and "deposited primarily on sandy intertidal flats … governed by the diminishing energy of tidal currents flowing shoreward across the gently-sloping tidal flats" with a tidal range of "between 5 and 10 m [16.4 and 32.8 feet]."

Others have suggested that some Tapeats facies have nothing to do with nearshore environments. Chadwick and Kennedy (2001, pp. 3, 4, brackets added) recognized that the "breccia extend for vertical distances of up to 140 meters [460 ft]" and "exhibit no evidence of post-depositional erosion or reworking prior to burial." They posited that "the widespread preservation of the breccia would require that … the unit existed below wave base," with a "water depth up to 200 meters [656 ft]." Berthault (2004, p. 481) thought that the Tonto Group originated initially "with the powerful current that eroded the granites and schist" of the Precambrian basement. As this erosive current, proceeding from west to east "advanced, the water depth increased, resulting in reduction of the current. The ensuing regressive current carried westward the largest particles in a bedload and the smaller ones in a suspended load." He suggested that Tonto Group deposition derived from this decreasing velocity current in one depositional episode.

While various authors have looked to facies to interpret the Tapeats, this study will instead examine hydrodynamics as a basis for interpretation, following the work of Barnhart (2011b), who showed that facies models could not explain the splay deposits of Hurricane Katrina. Sediments that would typically be attributed to repeated crevasse or overbank sedimentation in a deltaic environment were actually the result of a single depositional episode caused by catastrophic breaching of a levee in New Orleans. This mistake can be traced to the quasi-uniformitarian expectation that sediments are laid down under normal equilibrium conditions for particular facies. However, hydrodynamic studies of the individual layers demonstrated that strata were laid under catastrophic conditions, with little connection to the suggested facies, indicating that facies models can act as barriers to understanding the rock record.

Using a hydrodynamic approach, this series will take a new look at the Tapeats Formation. It will argue that layers within the Tapeats were deposited in hyperconcentrated flow conditions under an upper flow regime, with bedform height governed by flow depth. Determination of sediment concentration and rheological conditions will shed light on sedimentation rate, current velocity, and water depth during deposition. This is an introductory study and will not describe and interpret each layer of the Tapeats, but will instead provide an overview based on selected outcrops examined by the author. All bedforms suggest rapid deposition under extreme conditions: an overlay of storm waves on a violent flooding event resulted in continuous flooding onto a rapidly accreting surface, with limited evidence of reworking by the sediment-rich current, and no evidence of reworking by tidal currents.

This first paper will deal with the basal Tapeats—those layers immediately overlying the Great Unconformity. I will attempt to demonstrate that these layers were deposited under plastic flow conditions, affected by associated monadnocks and breccia flows caused by cascades of previously eroded rubble off of topographic highs. The second paper will deal with the middle and upper Tapeats; those layers are commonly cross-bedded and were probably deposited in a rheological regime of fluidal flow. Despite many incised channels and evidence of bidirectional flow, they were not deposited by tidal currents but by continued catastrophic flooding.

Hyperconcentrated Flood Flows and Debris Flows

The basal Tapeats in much of the eastern Grand Canyon is described by Chadwick and Kennedy (2001, p. 3, brackets added) as "alternating of light and dark layers of well-sorted graded sandstone beds. The debris flows [of breccia] generally lie immediately above these Tapeats beds." They cite Burgert (1972), who described these layers as turbidites. His attribution is unique and not cited in any other paper seen by the author. Hereford (1977, pp. 204, 206, brackets added) saw these strata that were "mapped by McKee … in the eastern Grand Canyon National Park" as his facies C, described as

> low (2°–10°) to medium (10°–20°) cross stratification, trough cross-stratification, tangential foresets, no alternation of coarse-fine foresets, continuous parallel stratification. Medium to coarse sandstone [0.24–0.48 mm], well sorted, pale red.

While I will differ with Hereford's (1977) facies approach, his "facies C" is comparable to the basal Tapeats layers analyzed below. But as McKee et al (1967, p. 850) observed after their work on the flood deposits of Bijou Creek, Colorado, "much of the layering is in the form of fine laminae similar to the type commonly ascribed to intermittent accumulation in quiet water over a long period of time."

This is a wise precaution as we consider a formation that most authors assume was deposited grain by grain under normal fluidal flow.

Were the basal Tapeats bedforms (Figure 3 and 4) produced by normal fluidal flow, where a grain-by-grain pattern of sedimentation occurs? In that situation, flow is fully turbulent and individual grains are deposited from bedload or suspension as they independently interact with turbulence vectors (Smith, 1986). Another possibility was noted by Smith (1986), who described sediment movement in hyperconcentrated flood flows. These are not fully turbulent, but sediment is partly supported by dispersive pressure (interaction between grains) and buoyancy. For example, the addition of as little as 2% colloidal clay or very fine sand can raise the fluid viscosity. He described hyperconcentrated flood flows as having 40–80% solids by volume (about 22–62% by weight) (Julien, 1998), suggesting significant sediment concentrations.

Smith (1986) thought that hyperconcentrated flood flow was intermediate

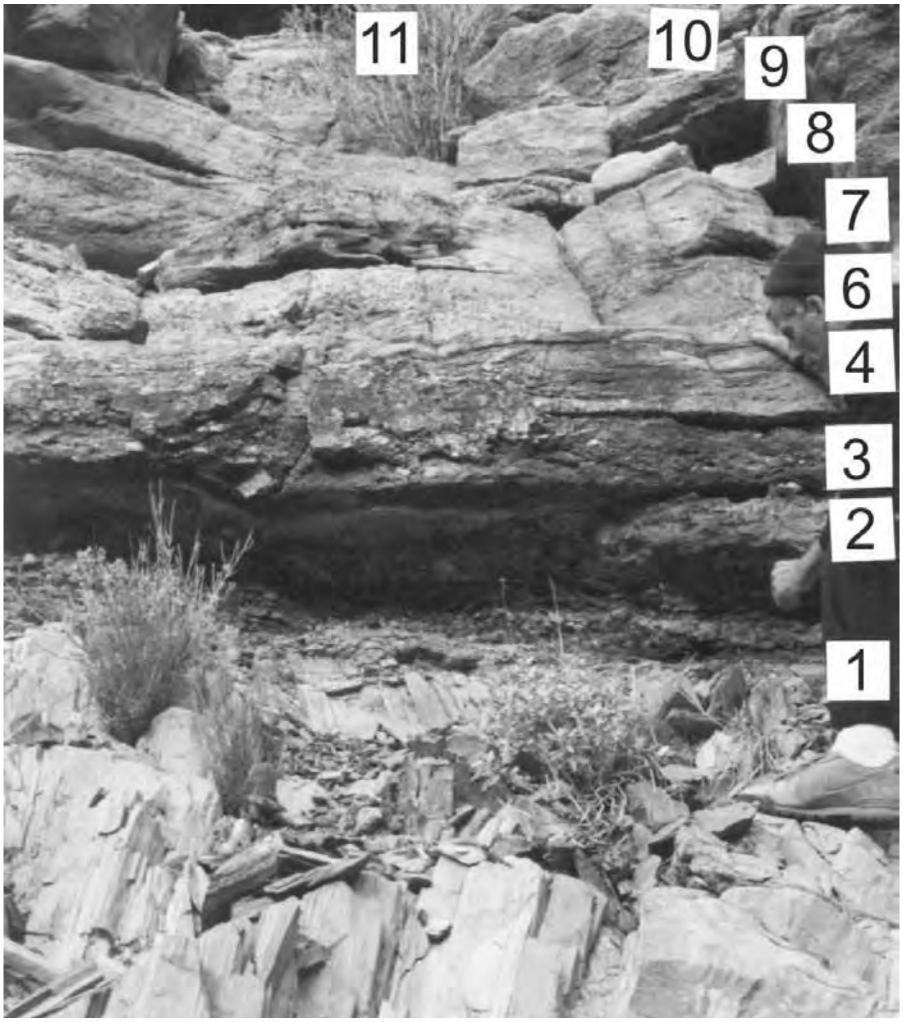


Figure 3. Great Unconformity and basal Tapeats Sandstone, Boucher Cabin site, Boucher Trail. Breccia at the contact is mica schist, similar to the substrate, the Vishnu Schist. Numbers show individual bedforms: (1) Clast supported with sand matrix. Material flowed downward to fill cracks and upwards to face layers 3 and 4 while still plastic. (2) Matrix supported conglomerate that terminates mid photo. (3) Higher proportion sand matrix with scattered clasts. (4) Sand layer with few small clasts. Intrusion of (1) covers face as a result of loading. (5) Layer is lens to right obscured by person. (6–7) Sand matrix with visible, 3–5 mm, ferruginous purple inclusions. (8) Cross bedded sand. (9–11) Laminar sand layers. See text for details.

between normal fluidal flow and fully plastic flow. Greater concentrations of sediment would cause deposition *en masse*. Shanmugam (1996) attributed a more plastic flow as the cause of what he called "sandy debris flows." Sandy debris flows can be identified by rafted large clasts transported by the flow density, inverse grading of entrained clasts toward the center of the flow, thoroughly mixed clasts and matrix, and the abrupt freezing of flows during deposition (Figures 5 and 6).

In the cross section of the basal Tapeats seen in Figure 3 from Boucher's cabin site (Figure 7), a variety of depositional products are observed, but none were caused by fluidal flow. A monadnock influences sedimentation here; although not immediately visible, its effects are evidenced in the first few layers, and the paleohill is either within the rock face or once existed in the open space behind the viewer.

The layer of breccia (Figure 3, Layer 1) was a product of localized erosion, as seen by the similarity of its small angular clasts of mica schist to the local substrate. This type of rubble field generally indicates an adjacent monadnock—the source of the eroded breccia. McKee (1945) recognized this association and assumed it originated from wave action against a monadnock, like that seen today where waves pound into marginal highlands. But that environment, implying lengthy time, would have rounded the clasts, which are soft. However, field observation shows sharp, crisply broken surfaces, indicating a very short period between erosion and burial of these breccia clasts.

At this location, it appears obvious that the basal Tapeats is not a beach deposit. There is no evidence of repeated wave action reworking sediment. Layer 2 was deposited, not grain by grain as fluidal flow, but as a presorted set of sediments in a high-density flow. It was initially deposited over the breccia of Layer 1 as plastic flow, and the absence of mixed breccia up into the sand shows no reworking. Even a single tidal cycle, with numerous waves pounding the gravel beach would have produced mixing. The small amount of breccia entrained in Layer 2 can be better explained as a small turbulence created by the arrival of a single wave whose actions were limited by the definite separation between Layers 1 and 2. Entrained breccia clasts are limited to the lowermost part of Layer 2; note their absence above the individual's left fist, barely 1 meter away from Layer 1 on the left. This indicates that the current's turbulent energy was dedicated to carrying sediment (Schumm and Kahn,

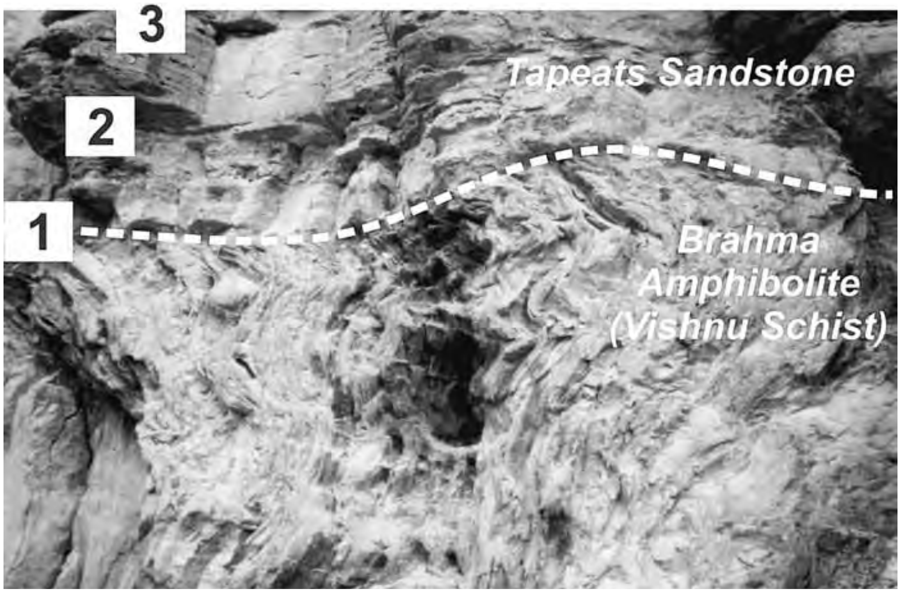


Figure 4. Great Unconformity and basal Tapeats Sandstone, Clear Creek Trail, about 1 km east of Phantom Ranch and Bright Angel Creek. (1) Great Unconformity. (2–3) Divisions between hyperconcentrated laminar layers of Tapeats. Scale = ~1.5 m across field of view.

1972). Its concentration of solids was sufficiently high to preclude any erosion by its turbulent head (Figure 8.3). There were no lapping waves; the continuing high current velocity was depositing high flow regime flat beds in the form of hyperconcentrated laminar flat beds.

Layer 3 contains a rectangular clast, 3 x 5 cm, the less dense mica schist. This clast was embedded in the lowest part of the layer as it rose and thinned over the monadnock. The entrained clasts are only about 1 cm (intermediate diameter, or d_B). These clasts moved only a short distance, once again illustrating the lack of repeated mixing and, therefore, turbulent flow in the current.

Layers 2 and 3 show unique elliptical internal fractures not seen in overlying layers. It is not clear if this is the convex dish structures cited in some accounts

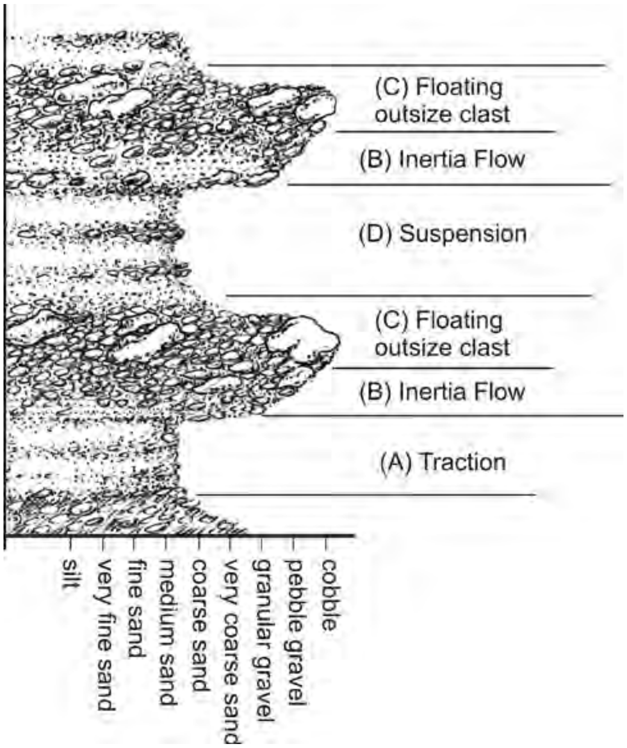


Figure 5.1. Idealized debris flow cross section as seen in combination of two examples interpreted as fan deltas. Labeling is a reflection of the part of the flow that deposited the section. C-B = reverse grading; D-C = normal grading. After figure 4 in Shanmugam (1996).

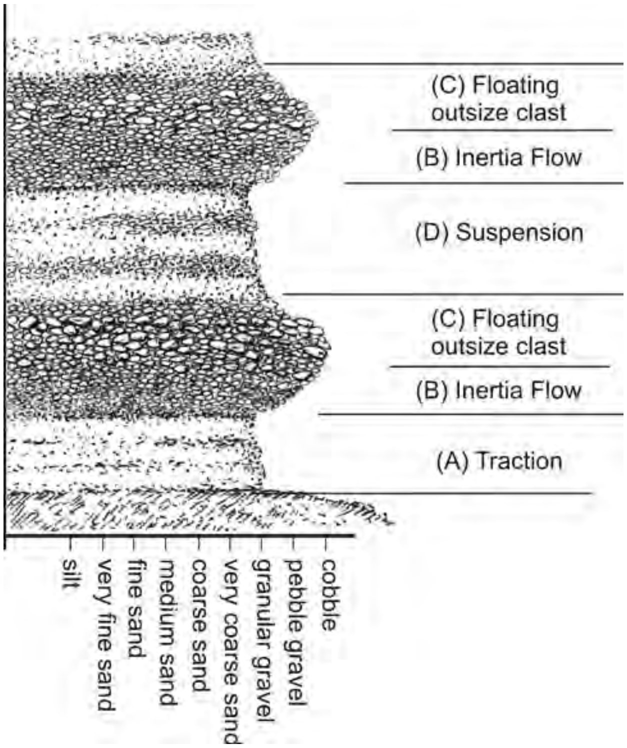


Figure 5.2. Sandy debris flow deposits in cross section. All clast sizes reduced to reflect the small differences in size between coarse sand and small pebbles. After figure 4 in Shanmugam (1996).

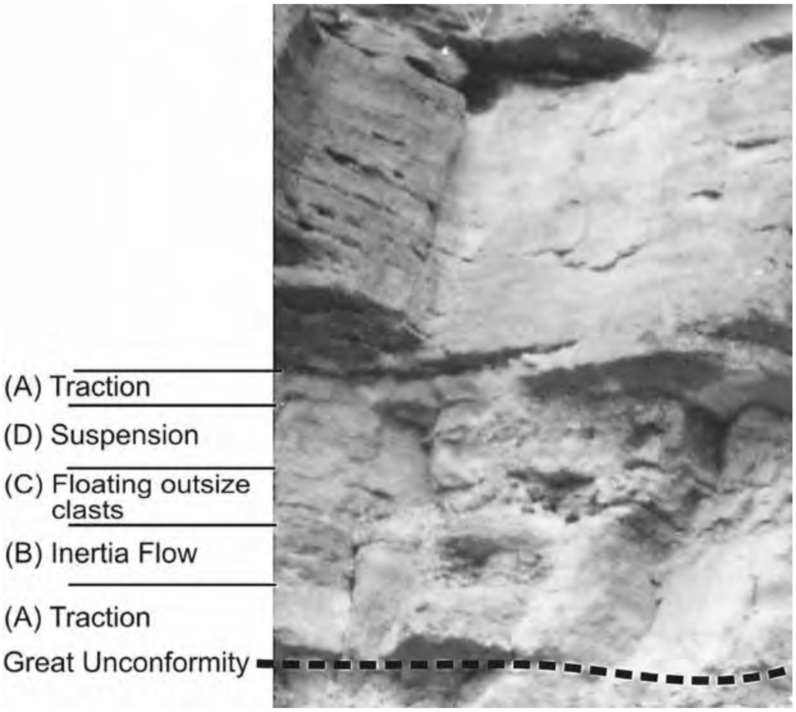


Figure 6. Upper left corner of Figure 4. A debris flow showing the same sublayers as Figure 5.

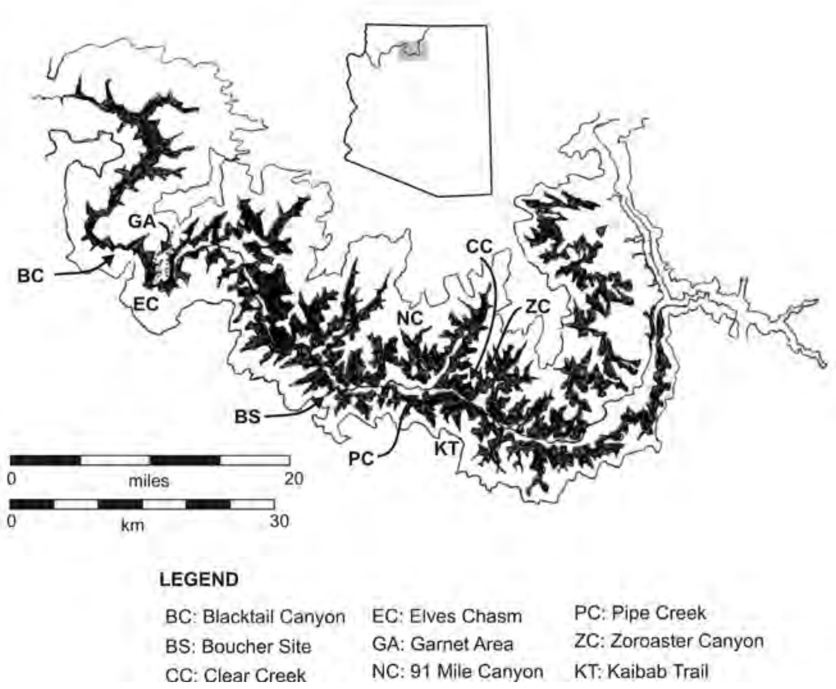


Figure 7. Locations in eastern Grand Canyon discussed in this paper. Dark areas represent exposures of Tapeats Sandstone and Bright Angel Shale. After figure 1 in Rose (2006).

of debris flows (Shanmugam, 1996), or incipient convoluted bedding per McKee et al. (1967), or an indication of decreased velocity of the hyperconcentrated flow (Barnhart, 2011b). To the left of the figure in layer 3, a distinct grouping of larger clasts can be seen in the middle of the layer. Floating clasts in the center of a layer is one of the distinct characteristics of a debris flow (Figure 5.2), where they ride on the increased density of the Inertia Flow (laminar flow) layer and under the bottom of the suspension (turbulent flow) layer. A visible inverse grading can be seen below the center, representing the laminar flow and normal grading from the turbulent, or suspension, flow overlays it up to the prominent light layer of white sand that would be in the right position for the traction band overlying Layer 4. A similar thin light layer can be seen under the ledge of Layer 3 and at the top of Layer 4. These distinct layers of white sand are interspersed between layers of sandy debris flows throughout the basal Tapeats. They appear to be a product of suction in the head of the high-density turbulent flow that has suspended the sediment in the viscous sublayer, sufficient to separate the finer fraction of white sand, and then relay it down flow as the sediment of the debris flow deflected the turbulence (Figure 8.3). The occurrence of a distinct, continuous traction layer indicates recurring adequate separation between depositional pulses in the flow to provide a break in sedimentation.

Shanmugam's (1996) diagram (Figure 5.1) illustrates these bands in the debris flows containing clasts of a broad size range. In the basal Tapeats, however, sediment distribution was limited by the sediments that were entrained. If a full range of clast sizes are not available, debris flow deposits will lack the clarity, as seen in Figure 5.2.

While Layers 2 and 3 show faint but well organized internal layering, Layer 4 and those above it show considerably more, though less regularly organized.

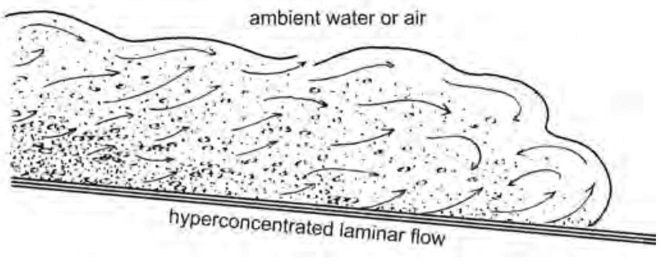


Figure 8.1. Hyperconcentrated flood flow as it would deposit hyperconcentrated laminar bedforms. Differs from high-density turbulent flow because all turbulence originates from substrate contact without significant turbulence generated at contact with ambient air or water. Note that no direction is inferred for Tapeats deposition in Figures 8.1–8.4.

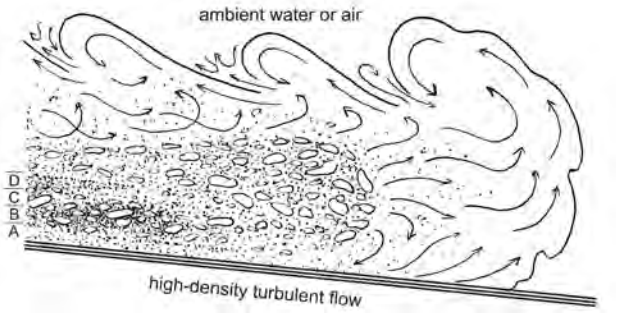


Figure 8.2. High-density turbulent flow in cross section as it would deposit a sandy debris flow based on high-density turbidites of larger clast size. Letters to left designate layers corresponding to those in Figure 5.1 After figure 4 in Shanmugam (1996).

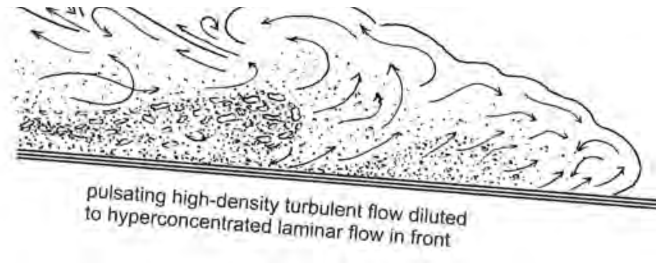

pulsating high-density turbulent flow diluted to hyperconcentrated laminar flow in front

Figure 8.3. Effects of pulsation in high-density turbulent flow would produce stacked bedforms. Formation of traction layer A requires pulse separation to allow settling of fines or pulses of sediment hydroplaning over the compressed layer of the inertia flow. After Sohn et al. (2002, their figure 1). Drawing horizontally compressed to show multiple pulses.

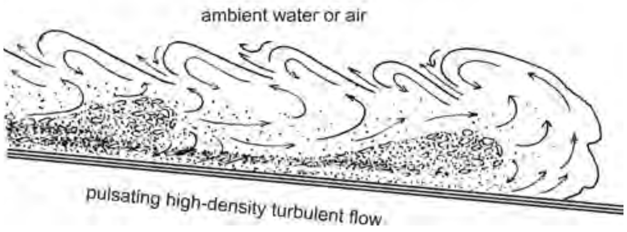


Figure 8.4. Pulses in high-density turbulent flow do not necessarily dilute to hyperconcentrated laminar flow at the leading edge, as in Figure 8.3. After figure 1 in Sohn et al. (2002). Drawing horizontally compressed to show multiple pulses.

These bedforms are similar to splay deposits formed during levee breaches in New Orleans during Hurricane Katrina (Barnhart, 2011b, his figure 7) and interpreted as hyperconcentrated laminar bedforms. Similar irregular, layered bedding is seen in the Toutle River valley west of Mount St. Helens (Figure 9), having formed by flooding following the May 1980 eruption (Smith, 1986) and sediments deposited at Bijou Creek, Colorado during the floods of June 1963 (McKee et al, 1967, their figures 5 and 7). Discontinuous laminae—<1 cm up to 3 cm thick—comprise each layer. The basal Tapeats contains a mixture of white sand laminae, medium-to-coarse white sand bedding, and a dark red to purple sand (sometimes called magenta or red sand) (Noble, 1922). McKee (1945) identified the dark sand as ferruginous sand, and Elston and Bessler (1977) identified the iron as syndepositional with the sand, not a diagenetic product. All of it occurs (Figure 10) at lower Elves Chasm Falls (Figure 7), just a few meters above the Great Unconformity. The lack of obvious patterns in the predominantly purple sediments demonstrates that sedimentary units are a product of the sediment entrained in the transporting current. Figure 11.1 shows the ubiquitous mixing of white and purple sediments at both the bottom and top of the section captured in that figure.

Hyperconcentrated flow deposits have been studied in subariel volcanic debris fields. Though there is no known volcanism associated with the Tapeats, the hydrodynamic principles behind the bedforms remain the same. They are typically more reliable than facies models in

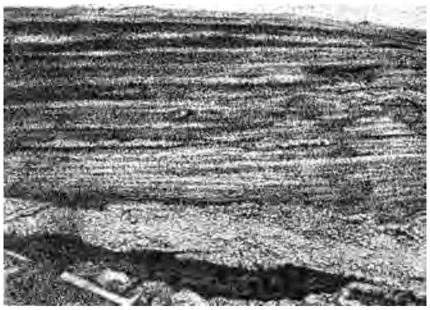


Figure 9. Hyperconcentrated flood flow from Toutle River valley debris field of Mt. St. Helens. Later arrival of horizontal flood flow did not displace dark and light oblique layers of loose pyroclastic deposits from May 18, 1980 eruption. After figure 4B in Smith (1986). Note discontinuous nature of layering.

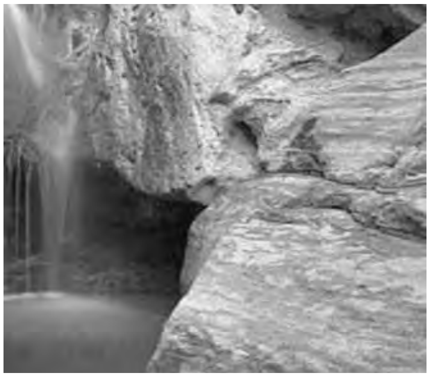


Figure 10. Close-up detail of laminar layers in lower Tapeats Sandstone. Mixing of purple ferruginous sand (gray bands) with white sand typical of such exposures. Modified from http://www.360parks.com/grand_canyon_colorado_river.shtml (accessed January 2011).

understanding the sedimentary process because hydrodynamic principles allow a quantitative assessment of actual depositional conditions, rather than some imagined "environment." Thus, the principles of hyperconcentrated flows in volcanic regimes can be applied to sedimentation in certain current conditions. Many hyperconcentrated flows begin as debris flows (Figure 8.2). Large debris flows can form with little water, but when they overflow into streams, lakes, snow packs, and other sources of water, they are diluted. The cogenetic contact of water and debris flow led Smith (1986) and Shanmugam (1996) to independently conclude that a debris flow would transform into a hyperconcentrated flood flow (Figure 8.1) when it entrained sufficient water to lubricate and dilute the flow. This situation would hold even for subaqueous debris flows (Figure 8.2), sometimes called hyperpycnal flow (a submerged high-density turbulent flow), where the turbulence is primarily restricted to its head and to the upper surface where ambient water is entrained.

Therefore, Layers 2 and 3 may represent debris flows where succeeding layers were deposited by the same current after it entrained sufficient water to dilute the slurry and change the rheological character of the flow.

In Figure 3, much of Layers 3 and 4 are hidden by a clastic veneer—a result of upward deformation of Layer 1. It is likely that overburden pressure was sufficient to crack brittle sandstone laminae, pressing them down into the still-plastic breccia. As a result, the plastic breccia migrated upward in response to loading. Such a sequence of events would have been rapid. Since the sandstone was already at least partially lithified when the overburden accumulated, then its initial cement would have been present as intergranular ions, possibly entrained in the flow itself. Cementation would have been quite rapid and not a result of slow percolation of later pore fluids. In that case, both the sandstone and the breccia would have been cemented, and the deformation observed would have been impossible.

Layer 6, with its many purple spots, strongly resembles Layer 1 of Figure 4. Both contain small voids, suggesting a similar origin for the layers. However, the deposits in Figure 4 and those in Figure 3 are about 16 km apart (Figure 7) and on opposite sides of the Colorado River. The small vugs often contain small secondary crystal growth, which suggests lithification before the deposit was compacted by overburden. If the vugs formed during deposition, then as a natural part of the lamination structure, the voids must have formed simultaneously with the bedform. That would preclude deposition grain by grain in a fluid flow, because the increased viscosity of the fluid due to fine sand in suspension would have prevented air from escaping (cf. Klein, 1970, his figure 15A).

We can only speculate about the original vug fill. It might have been original fluids, forming vugs during cementation, or just air bubbles, as documented by Klein (1970) in sediments deposited across the top of a sand bar in the Bay of Fundy, Nova Scotia, which I would interpret as hyperconcentrated laminar bedforms. Regardless of what they originally contained, they testify to the rapid deposition, burial, and lithification before loading of what was originally a cohesive plastic mass.

The upper layers (Layer 4 and above) were rapidly deposited by a hyperconcentrated flow (Smith, 1986). By analogy, it probably had a concentration of solids close to 20–30% by volume (Lowe, 1982; Barnhart, 2011b) or as high as 60% (Pierson and Costa, 1987).

Under these depositional conditions, it is likely that the laminar or bedding thickness is proportional to the depth of the depositing current. According to Allen (1976), this ratio would have been on the order of 6:1 to 8:1. Since Layer 4 is 12–16 cm thick, its depositing current would have been only 0.72–1.28 m deep. This is significantly less than the 50–60 feet of McKee (1945) or the 200 m of Chadwick and Kennedy (2001). The difference is based on the primacy of facies models and environmental conditions assumed by these authors, rather than a quantitative assessment

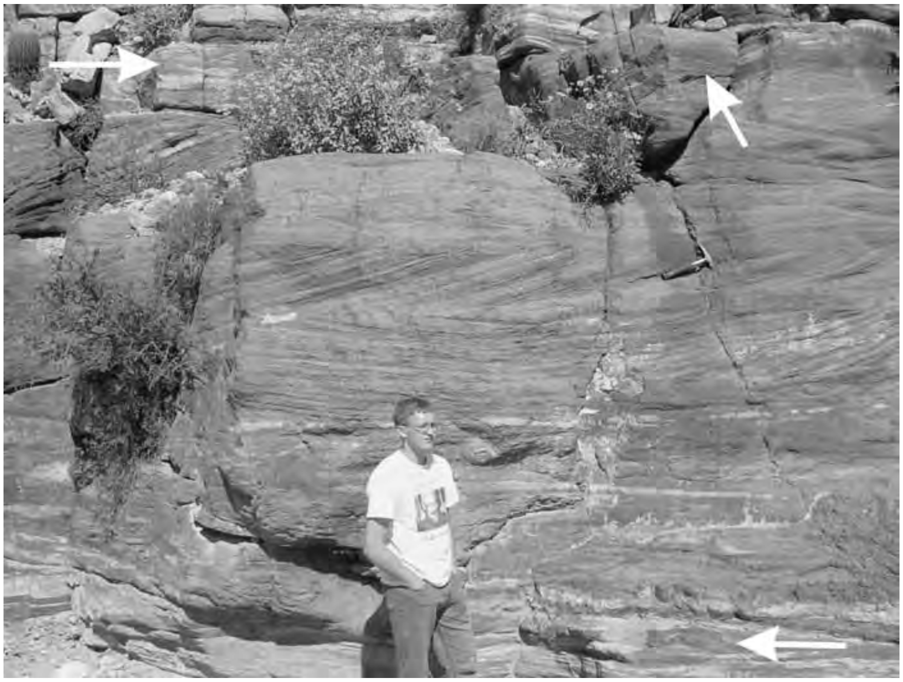


Figure 11.1. Tapeats Sandstone, labeled "Peach Spring Canyon" but with strata matching that east of Pipe Creek. Layers showing repeated hyperconcentrated laminar bedforms at the bottom and near top, with ferruginous (purple) sand (arrows) layered with white sand, traction layers. Cross bedding in center the result of sandy debris flows. From http://web.mst.edu/~rogersda/umrcourses/geo372/2005–03–27–109-Peach_Springs_Canyon-cross_bedding.JPG (accessed December 2010).

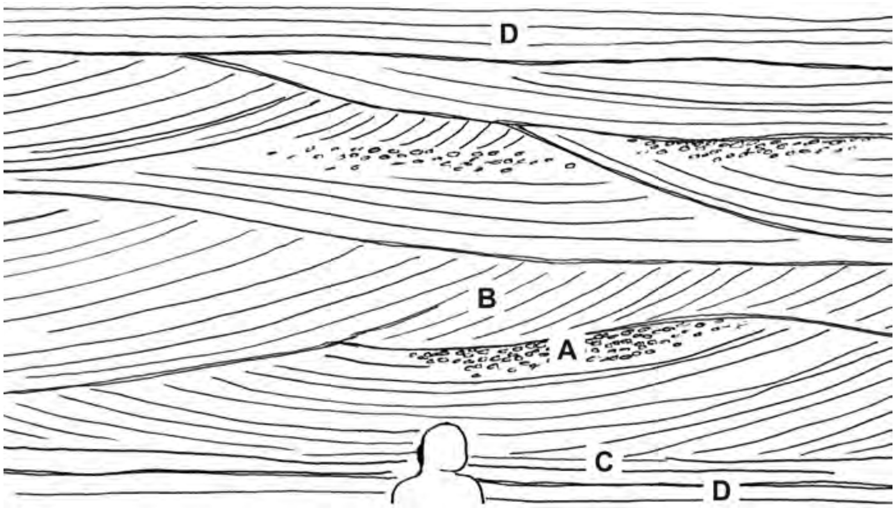


Figure 11.2. Sketch identifying: (A) disorganized outsized rafted clasts of coarse sand and small pebbles, (B) general trend of trough cross bedding, (C) traction layer of white sand at the bottom of trough cross bedding, or at the top of (D) hyperconcentrated laminar bedforms both below and above.

of hydrodynamics of the deposit itself. Those authors believed that the coarse sand was deposited below wave base in a marine environment. In contrast, this paper proposes that the layers reflect wave surges superimposed on a strong unidirectional current. Furthermore, high-velocity flat beds cannot form in deep water (McBride et al., 1975; Smith, 1971), which requires higher velocity to maintain competency (Grant, 1997). Rapidly accreting high-velocity flat beds typically do not form in deep water; instead, sediments are usually reworked at depth. Layers 6, 7, 9, and 10 are about the same thickness, suggesting shallower water persisted, probably over a broad area. This is similar to the Katrina splay deposits, which were influenced by the mass of Lake Pontchartrain, as well as by the width of the levee breaches. These factors influenced flow depth and rheology, and thus the resulting bedforms (Barnhart, 2011b). Layer 5 is not sufficiently visible to evaluate, and Layer 8 is appreciably thinner by contrast, showing another rhythmic pattern that will be discussed in the next paper of this series.

The visibility of the characteristics in the layers of Figure 3 result primarily from their location inside a large conchoidal overhang. Here, the rock fractured and broke loose along planes that reflect different stresses in each layer, suggesting distinct conditions for each layer.

These bedding differences are visible 24 km to the west at lower Elves Chasm (Figure 7). Figure 12 shows a part of an 8 m-tall exposure of the Tapeats on the right. Each layer was rounded by a current. These beds are stratigraphically higher, representing the transition up into the middle Tapeats, despite being only a few meters above the Great Unconformity. At this location, there is a greater variation in thickness of these beds, which are coated by desert varnish. Thickness varies from 1–16 cm, as seen at Boucher (Figure 3, Layer 8). That thickness variation is also visible in the

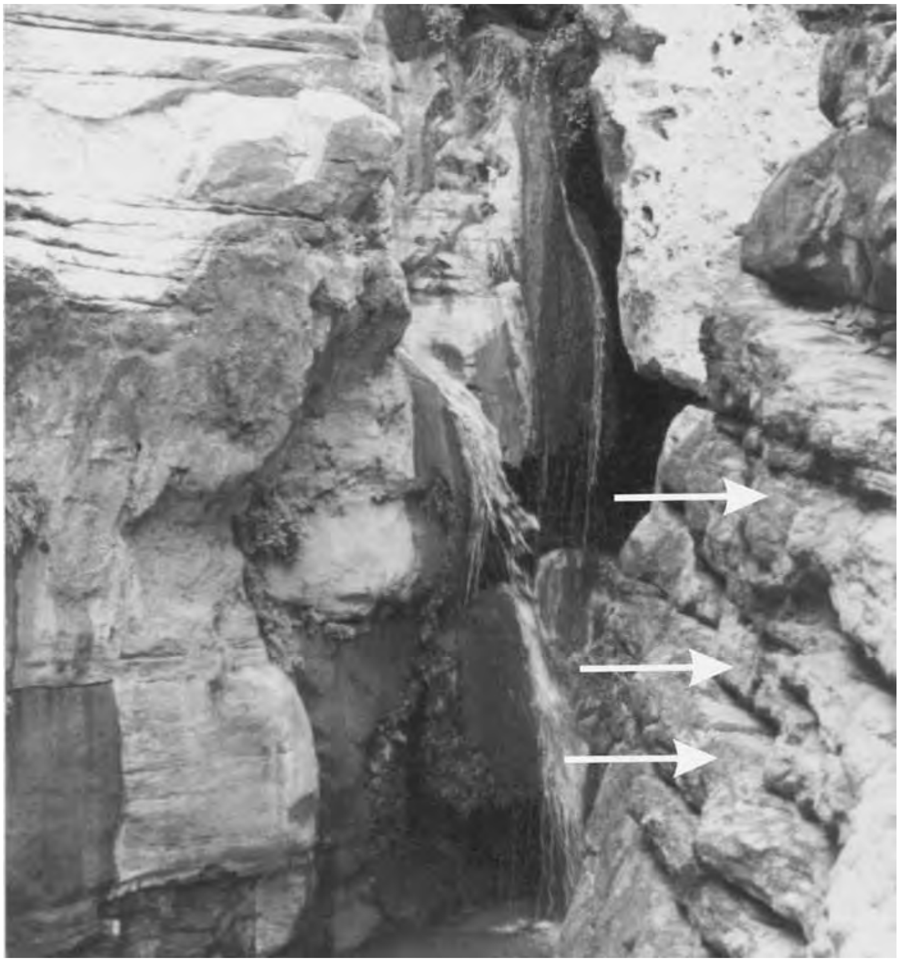


Figure 12. Laminar layers near the bottom of the Tapeats at lowest falls, Lower Elves Chasm. Purple layers (white arrows) with nearest layers at lower right, typically 3–16 cm thick.

light rock to the left of the falls. However, an additional tapering of many bedding planes can be seen within the near layers on the right. These are low-angle foreset bedding planes that McKee et al (1967) and Barnhart (2011b) determined to indicate decreasing velocity. They suggest the increasing mixing of ambient water with the debris flow and would appear as the plastic flow transitions to a more fluidal flow.

Figure 10 illustrates the bedding near the water level at the base of the falls in Figure 12. The irregular layering of purple and white laminae is typical of hyperconcentrated laminar bedforms. Thus, it appears that all of these sediments were deposited from a plastic flow throughout the section visible in Figure 12. This suggests rapid deposition with another regular overlying energy pattern.

Figure 13, at Red Canyon, is at or near the top of the Tapeats—the transition zone of McKee (1945). Individual layers are approximately the same thickness as those at lower Elves Chasm falls (Figure 12). Though this pattern is not constant through the entire thickness of the Tapeats, the next paper in this series will argue that depositional conditions were similar throughout. The ubiquitous purple sand can be seen here as a dark streak across the large rectangular block just right of lower center and as the dark layer between lighter layers in the overhanging ledge above the block's far end.

About 7 km further west at Blacktail Canyon is another exposure of the basal Tapeats at the Great Unconformity. In Figure 14 a clast of rounded quartz is suspended in a sand matrix to the right of the image. The clast's position indicates plastic behavior in a sandy debris flow (Figure 5). This is contrary to the quiet tidal environment posited by many geologists. In a fluvial or marine tidal setting, the sediment would have been carried in water with a low concentration of solids and with no dispersive shear stress; thus, the most prominent stress on the quartz clast would have been from traction in the bedload. Finer grains would have been carried higher in the suspended load over the saltating larger clasts. In that case, saltation and rolling would have continued until local traction stress halted the progress, most likely in a small cluster of grains. In this case, the clast would have been deposited with its longest axis, d_A, perpendicular to flow. A rolling cobble naturally turns its intermediate and short axes, d_B and d_C respectively, parallel to flow to facilitate rolling with minimal energy expended (Smith, 1986). Since d_A is parallel to flow, the quartz was suspended in a matrix with d_C perpendicular to flow, again following the least resistance. Suspending a cobble of this size would require a viscosity higher than water; it would require plastic flow. If the bedforms were deposited in a plastic debris flow, then what was the current velocity?

Velocity of the Basal Tapeats

The floating quartz clast in Figure 14 allows a minimum velocity calculation for the flow depositing the basal Tapeats. It is the minimum because a higher velocity would entrain the clast. Scale is uncertain in this photo, but using a length of 7 cm for the index finger, the quartz is 3.8 x 7.7 cm, and the layer is

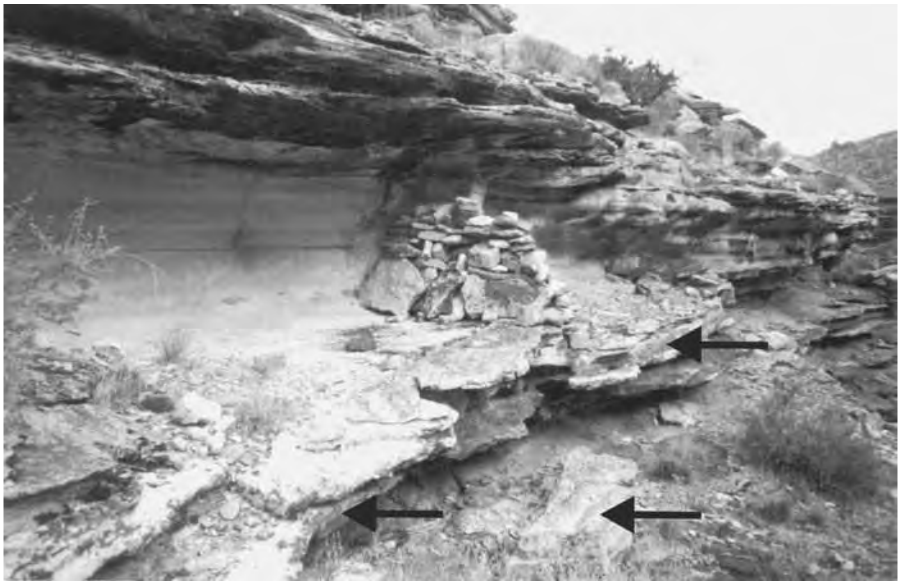


Figure 13. Laminar layers near the top of the Tapeats, Red Canyon, typical of exposures in the eastern Grand Canyon. Eroded alcove about 1 m high, with typical layers 3–16 cm thick. Some purple layers marked by arrows.

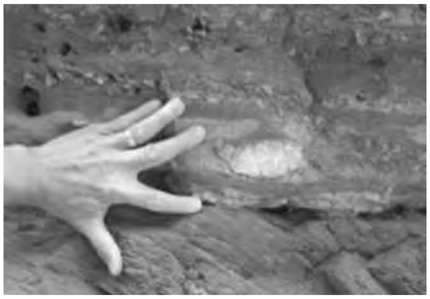


Figure 14. Contact of basal Tapeats Sandstone at Great Unconformity with gneiss below. Quartz clast is about 3.8 x 7.7 cm in the middle of a 10.5 cm layer. From area of Blacktail Canyon. Modified from http://www.thegreatstory.org/great-unconformity.html (accessed December 2010).

10.5 cm thick. For these hydrodynamic calculations, the following symbols will be used:

γ_s = specific gravity of the solid phase

γ_m = specific gravity of the water/solid mixture based on the percent concentration of solids

d = diameter of the sediment particles

τ = total shear stress

τ_* = dimensionless shear stress for the solid particles

τ_o = critical shear stress for initiating particle motion

h = flow depth

S = slope steepness factor

f = friction factor

μ = dynamic viscosity of water

μ_m = change in dynamic viscosity for mixture

V_o = critical velocity initiating particle motion

$\overline{V}$ = depth averaged flow velocity

Fr = Froude number

e = natural log

The critical shear stress (τ_o) can be determined from the Shields equation (Julien, 1998):

$$\tau_o = \tau_* (\gamma_s - \gamma_m)\, d_{max} \qquad (1)$$

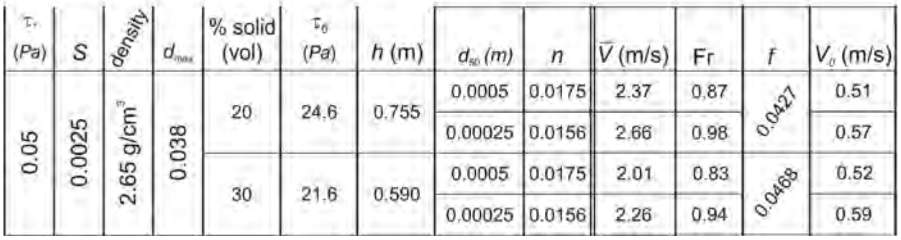
Julien (1998) gives $\tau_* = 0.05$ for very coarse gravel (>32 mm), 2.65 g/cm^3 is the density of quartz, and $d_{max} = 3.8$ cm, the d_B measurement calculated from Figure 14. For a non-Newtonian fluid, Julien (1998) gives the range of 5–60% solids by weight for hyperconcentrated flows. Lowe (1982) preferred a narrower range of 20–30% solids by volume, about 42.1–52.0% by weight (based on Julien's, 1998, p. 174 conversion). To reach a 25% concentration by volume, a 46.9% concentration by weight would be required. The higher concentrations produce lower values for critical shear stress (τ_o), flow depth (h), and velocity (V). Using the analogy of the Katrina splay deposits, I want to compare the two bedforms. Therefore, I am providing parallel calculations with the same 20–30% solids by weight used for the splay deposits. This gives a range of values: $\tau_o = 21.6$ N/m^2 for 30% solids and 24.6 N/m^2 for 20% solids (Table I).

The DuBoys equation (Lalomov, 2007) calculates flow depth (h) from critical shear stress (τ_o):

$$h = \tau_o / \gamma_m S \qquad (2)$$

For slope (S), Hereford (1977) provided sedimentary evidence of braided

Table I. Minimum Velocities
calculations based on clast size d_B = 3.8 cm (Figure 14)



τ_* (Pa)	S	density	d_{max}	% solid (vol)	τ_o (Pa)	h (m)	d_{50} (m)	n	$\overline{V}$ (m/s)	Fr	f	V_o (m/s)
0.05	0.0025	2.65 g/cm^3	0.038	20	24.6	0.755	0.0005	0.0175	2.37	0.87	0.0427	0.51
							0.00025	0.0156	2.66	0.98		0.57
				30	21.6	0.590	0.0005	0.0175	2.01	0.83	0.0468	0.52
							0.00025	0.0156	2.26	0.94		0.59

stream deposition for the Tapeats. Schumm and Khan (1972) noted that flume evidence shows that braided streams require a minimum slope of 0.016. Using $S = 0.017$, a flow depth of $h = 0.11$ m, is obtained for flow with 20% solids and $h = 0.087$ m for 30% solids by weight. Because these depths are too shallow to produce layers of 0.105 m, they were not deposited on a slope steep enough for a braided stream.

Another option is found from the work of McKee et al. (1967, p. 839, brackets added) on the Bijou Creek flood deposits. If these were hyperconcentrated flow products (Barnhart, 2011b), "the flooded surface must have been quite irregular, as shown by variations in thickness of sand deposits [his figure 6: (6 - >30 in)] despite a relatively flat, even top." McKee et al. (1967) determined the height of sediment deposited under a wide flooding current was directly related to the elevation of the top of the current, not the variations in the topographic substrate. While they could not or did not determine what the flow depth to sediment height ratio was in the Bijou Creek flood, that calculation in similar situations can help answer the question of depth.

Barnhart (2011b) determined that the Katrina splay deposits exhibited a ratio between depth and bedding thickness of 8:1 to 10:1, and Allen (1976) thought 6:1–8:1 was typical. Based on these values, Equation (2) was solved for slope (S) when $h = 0.63$–1.05 m. The resulting range for the slope was 0.0014 to 0.0030. A median value, $S = 0.0025$, was used. Substituting it back into Equation (2), flow depth would have been in the range of $h = 0.59$–0.76 m (Table I). While there is no physical evidence to determine the actual sub-Tapeats slope, the comparison of these two slopes, 0.017 and 0.0025, shows that a shallow slope better fits the hydraulic data.

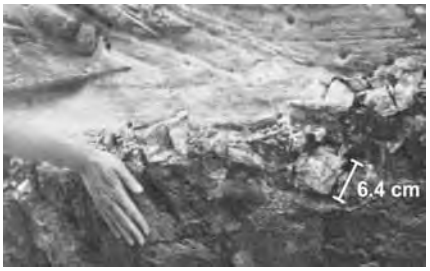


Figure 15. Detail of Tapeats breccia at Great Unconformity.

The Manning Equation (Julien, 1998) is used to calculate depth-averaged flow velocity ($\overline{V}$):

$$\overline{V} = S^{1/2} h^{2/3} n^{-1} \tag{3}$$

The value of the Manning coefficient (n) for all sizes of sand to fine gravel is $n = 0.02$ (Julien, 1998). He also provided an alternate method of deriving the coefficient directly from the grain size (p. 97) as $n = 0.062\, d_{50}^{\,1/2}$. This gives $n = 0.0175$ for medium sand (0.0005 m) and $n = 0.01556$ for fine sand (0.00025 m). McKee (1945) identified both in the basal Tapeats. Based on these factors, the basal Tapeats depositional depth-averaged velocity ranged between 2.01 and 2.66 m/s (Table I).

The Froude number is a ratio of the inertial forces to the gravitational forces and is derived from the equation (Julien, 1998, p. 38):

$$\mathrm{Fr} = V\,(gh)^{-1/2} \tag{4}$$

High-energy flows will move at depths and velocities that approach Fr = 1.0 in order to maximize energy dissipation and sediment transport (Julien, 1998). Grant (1997 p. 349) stated that Fr > 1.0 would occur only for short periods of time without adjusting "the channel hydraulics and bed configuration." Costa (1987) showed that under the very high energy of flash floods, Fr > 1.0. Kennedy (1963, p. 539) defined the critical flow range between Fr = 0.844 and Fr = 1.0. Here, Froude numbers are a means of checking the relationship between h and V, based on the tendency for Fr to approach 1.0. Table I shows Fr = 0.83 to 0.98, within the acceptable range of expected flow.

Table I shows minimum velocities. Maximum velocities are shown in Table II, based on data from Figure 15. Sedimentary features there also show a plastic rheology, with contemporaneous currents interacting to deposit the sediments quite rapidly. Figure 15 shows breccia that was not entrained in the flow but left between the base of the flow and the Great Unconformity. Unlike Figure 3 at Boucher, the breccia was not against a high limiting the current's ability to pick up additional sediments. The flat beds of breccia visible in the next bed up of Figure 16 testify to this. Since the clast in the foreground was not entrained, calculations based on its size will provide maximum possible flow velocity. The two locations (Figures 14 and 15) are about 40 km apart, illustrating the proposed extent of the currents responsible for the basal Tapeats deposition.

Many clasts in Figure 15 are broken or eroded; the marked clast has a $d_B = 0.064$ m (based on a 7-cm index finger).

Table II. Maximum Velocities
calculations based on clast size d_B = 6.4 cm (Figure 15)

τ_y (Pa)	S	density	d_{max} (m)	% solid (vol)	τ_0 (Pa)	h (m)	d_{50} (m)	n	$\overline{V}$ (m/s)	Fr	f	V_0 (m/s)
0.05	0.0025	2.65 g/cm³	0.064	20	41.5	1.274	0.0005	0.0175	3.36	0.99	0.0426	0.56
							0.00025	0.0156	3.77	1.11		0.63
				30	36.3	0.991	0.0005	0.0175	2.84	0.91	0.0469	0.55
							0.00025	0.0156	3.19	1.02		0.62

Repeating the calculations for critical shear stress (1), flow depth (2), and velocity (3) yields the results in Table II; slope and the Manning coefficient are the same in both tables. Flow depth for the basal Tapeats thus ranged between 0.59 and 1.27 m, and depth-averaged flow velocity from 2.01–3.77 m/s. The maximum values for depth and velocity yield Froude numbers near unity.

Can we validly analyze flows with plastic rheology with formulas developed for fully turbulent flow? For a plastic flow to move, it must have a shear stress equal to the yield strength (τ_x) plus the dynamic viscosity of the mixture (μ_m). These quantities are dependent on the concentration by volume of the solids (C_v) and do not vary based on the d_{max} of the solids. Therefore, Shield's Equation (1) is not the best formula for this case.

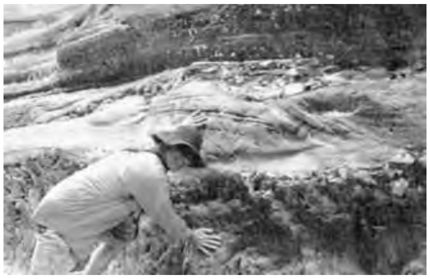


Figure 16.1. Tapeats Sandstone at Great Unconformity, possibly at Pipe Creek.

Julien (1998, p. 188) provided a formula for stress (τ) in a plastic flow, where dv_x/dz is the rate of deformation and said to "rarely exceed 100/s" in natural settings (Julien, 1998, p. 120):

$$\tau = \tau_y + \mu_m dv_x/dz \qquad (5)$$

For finding the yield strength in sand, Julien (1998, p. 190) devised the following formula from the graph of multiple data sets:

$$\tau_y\,(Pa) = 0.1e^{\,3(Cv - 0.05)} \qquad (6)$$

While the sand portion of his database is sparse, and I prefer a different best-fit line, varying the line does not produce a significantly larger value for the yield strength. In sand, the formula produces $\tau_y = 1.05\ Pa$ for 20% solids and $\tau_y = 2.39\ Pa$ for 30% solids (Table III).

For finding the change in dynamic viscosity (μ_m) of the mixture, Julien (1998, p. 190) recommended for sand:

$$\mu_m = \mu(1 + 2.5\,C_v + e^{\,10(Cv - 0.05)}) \qquad (7)$$

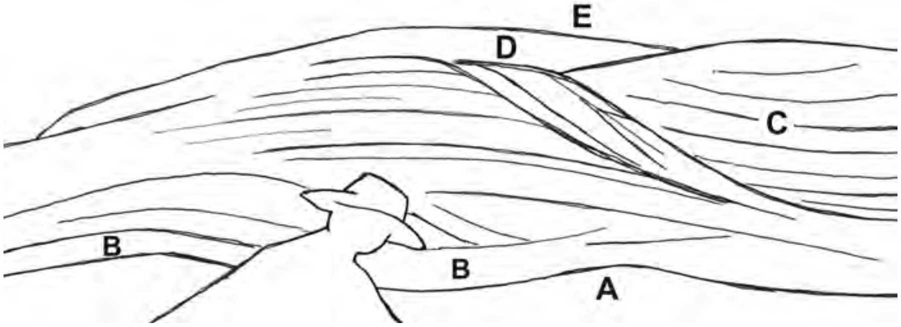


Figure 16.2. Sketch of Figure 16.1 showing: (A) breccia layer with sand matrix at unconformity, (B) traction layer of fine sand, (C) cross bedding of medium to coarse sand, (D) upper breccia layer conformed to uneroded rolling top of cross bedding, and (E) laminar bedded breccia grading into sand.

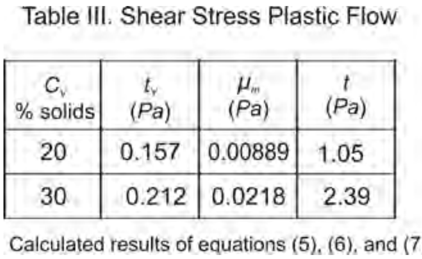


Table III. Shear Stress Plastic Flow

C_v % solids	t_v (Pa)	μ_m (Pa)	t (Pa)
20	0.157	0.00889	1.05
30	0.212	0.0218	2.39

Calculated results of equations (5), (6), and (7)

This produces values of $\mu_m = 0.00889\ Pa$ for 20% solids and $0.0218\ Pa$ for 30% solids (Table III). Even when a maximum value of $dv_x/dz = 100/s$ is used, together these values in formula (5) give $\tau = 1.05\ Pa$ for 20% and $2.39\ Pa$ for 30% (Table III). These values are a full order of magnitude smaller than the τ_o calculated form turbulency formulas based on clast size in Table I. In a sandy debris flow, the shear stress can be measured by the yield strength (τ_y), and the dynamic viscosity of the mixture (μ_m) may have little to do with the shear stress needed to entrain larger clasts in the flow. Of course, the energy needed to start flow may be much greater than the yield strength. This extra energy becomes concentrated in the turbulent head and upper surface of the flow (Figure 8.2). This suggests our mathematical understanding of plastic flow is still incomplete when working with sand at the high levels of energy exhibited in the Tapeats Sandstone.

A second way to evaluate the results of calculations in Tables I and II is to compare the velocities obtained with the known critical velocity needed to move clasts of known d_{max} from experimental data. Berthault (2004) cites Lischtvan-Lebediev (1959), who charted the critical velocity (V_0) for many clast sizes at multiple flow depths. A small part of this chart is reproduced in Table IV.

For a comparison with the calculations of depth-averaged velocity ($\overline{V}$) in Tables I and II, critical velocity (V_0) can be calculated by the formulae provided in Rubin and McCulloch (1980, p. 217) based on Keulegan's (1938) classic work:

$$V_0 = \overline{V}\ (5.75 \log (0.37\ h/f))^{-1} \tag{8}$$

The additional variable (f) is a friction factor and Keulegan's (Lalomov 2007, p. 276) is provided as:

$$f = (2.03 \log (12.2\ h/d_{max}))^{-2} \tag{9}$$

Friction factors (f) from 0.0426–0.0428 are calculated (Tables I and II) and produce critical velocities (V_0) with formula (8) from $V_0 = 0.51 - 0.63$ m/s.

Table IV shows the comparison of Lischtvan-Lebediev's (1959) results with the calculations from Table I for minimum velocities. With allowances made for differences in flow depth and percent concentration of solids, the results from Table I correspond well with the rest of the sequence. This provides confidence that both depth (h) and depth-averaged velocity ($\overline{V}$) as calculated in this paper are realistically in agreement with modern measured data. While the equations for plastic flow may not give us any more information about what is taking place behind the fully turbulent head of the high-density turbulent flow (Figure 8.2), the head is acting in complete accordance with other fully turbulent flows.

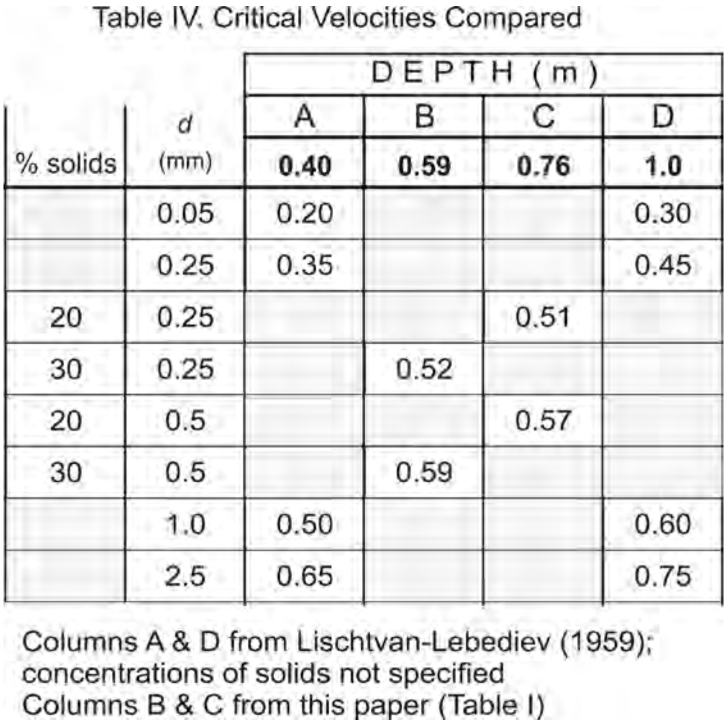


Table IV. Critical Velocities Compared

		DEPTH (m)			
	d	A	B	C	D
% solids	(mm)	**0.40**	**0.59**	**0.76**	**1.0**
	0.05	0.20			0.30
	0.25	0.35			0.45
20	0.25			0.51	
30	0.25		0.52		
20	0.5			0.57	
30	0.5		0.59		
	1.0	0.50			0.60
	2.5	0.65			0.75

Columns A & D from Lischtvan-Lebediev (1959); concentrations of solids not specified
Columns B & C from this paper (Table I)

Smith (1986) noted that the presence of cobbles in the same flow with sand demonstrates enough kinetic energy to carry the fine sand in suspension; at sufficient concentrations, the entrained sand would dramatically affect fluid viscosity and carrying capacity. Thus, conditions for the basal Tapeats may well have been close to the maximum values of Table II. Keeping Fr close to 1.0 provides a check on any set of conditions.

But why was the fine sand of the traction layer not eroded by these high velocities? One answer is that deposition occurred from a hyperconcentrated flow, under plastic conditions behind the turbulent head, in a unidirectional current overlaid by energy pulses, such as would be expected from storm waves. Figure 8 illustrates this type of current. Figure 8.1 shows that the only part of such a current where turbulence contacts the substrate is at the turbulent head. Behind it, laminar flow at the substrate/current interface shields the substrate. Because all of the water is moving as a part of a continuous current, a second and third wave of bedforms (Figure 8.3) would override the first, leaving additional layers while not exposing the substrate to additional turbulence from the current's head.

If distinct layers were deposited by pulses of energy or sediment, what caused these pulses? Foley and Vanoni (1977) described how bore waves are generated by the continual breaking of standing waves and the release of stored water from them at certain conditions of shallow flow depth and velocities close to critical. These standing waves are generated by growing antidunes beneath them. Bore wave periods vary from 44 sec at 0.471 m/s to 7.8 sec at 0.275 m/s (Foley and Vanoni, 1977).

Julien (1998) speculated that at Fr = 1, wave celerity should equal current velocity, causing wave and current to travel synchronously. It seems apparent that he is referring to deepwater waves. Deepwater waves are limited by flow velocity, which breaks them into multiple shallow waves (Barnhart, 2011b). Dispersal pressure acts on an isolated wave front (McLane, 1995), breaking a single wave into multiple waves. It follows that a current can also be broken into multiple energy wave fronts. Storm waves superimposed on a current can produce such pulses. Where there is a flux in current energy that changes the elevation of the flow surface, such as bore waves cited by Foley and Vanoni (1977), there is a corresponding change in the thickness of the boundary layer (Ippen, 1951). Such a rise in the boundary layer will produce a change in pressure at that point in the flow; this could be the initiating factor for a new layer of sediment.

Smith (1986) in the Neogene Deschutes Formation, central Oregon, and Sohn et al. (2002) in the Cretaceous Cerros Toro Formation, Southern Chile, both document rheologic changes from a subaqueous debris flow to a hyperconcentrated flow producing laminar bedforms caused by dilution of the flow (Figures 8.3 and 8.4), extending over 10's of km. Lamb et al. (2010, p. 1070) note that hyperpycnal flows (high-density turbidity currents under ambient water) remain coherent for extended periods after plunging and can experience "multiple acceleration and deceleration … due to the intrinsic phenomenon of plunge point translation for even the most simple flood hydrograph and bed topography." Sohn et al. (2002) provide a model for multiphase or pulsating forms of these flows (Figures 8.3 and 8.4) as they divide and/or hydroplane as a result of the additional entrained water.

What was the period of these bedforms that compose the basal Tapeats? While calculations (Table I) suggest fairly shallow flow, under 1.5 m, the period of shallow water waves is too low. While they may have influenced deposition higher in the formation when flow became less plastic, the depositional current requires longer waves. McLane (1995, p. 72) suggested a storm wavelength of 600 m would have a period of about 20 seconds. Because these are fairly thick layers, the wavelength may need to be even longer. A wavelength of 1000–1200 m would result in a period of about 40 seconds. Based on a mean layer thickness of 10 cm and on each layer being deposited by a storm wave, sedimentation would proceed at a rate of 1 m every 400 sec or 0.15 m/minute. If single wave fronts divided into multiple waves, creating the possibility of overlying patterns of shallow water waves, this rate could be even faster. Katrina splay deposits showed six recognizable wave crests from each deepwater wave. This would produce a sedimentation rate of an amazing 0.9 m/minute.

Trough Cross Bedding and Debris Flows

Hereford (1977, p. 206) described various facies of the Tapeats in the Chino Valley area of central Arizona (Figure 2). His "facies C," in the basal Tapeats, was characterized as: "low (2°–10°) to medium (10°–20°) cross-stratified, trough cross-stratified tangential foresets, no alternation of coarse-fine foresets." McKee (1945) identified trough cross bedding cut into flat beds of the basal Tapeats in the eastern Grand Canyon. Rose (2006, p. 228) may have called the same feature "amalgamated channels of tangentially cross-bedded arkosic to subarkosic coarse to very coarse to gravelly sandstone." Though cogent, he was describing rocks higher up in the Tapeats Formation.

It is worth reexamining McKee's (1945) "trough cross bedding," which he documented at four locations (Figure 17), noting the angles of repose of 23° and 27°. Since these angles correspond to the erosion surface and are not the same through the thickness of the deposit, had the erosion scoured less, the angles also would have been less and would have matched more closely the 2°-20° Hereford (1977) recorded in central Arizona. McKee's (1945) four locations are relatively grouped and are all adjacent to monadnocks. He identifies the bedforms at each one as "scour and fill structures" (p. 43). McKee (1945) interpreted the features as bedding created by migrating sand dunes filling channels previously cut by accelerated currents. That is the common explanation of trough cross bedding (McLane, 1995; Nichols, 1999). However, McKee (1945) failed to notice several subtle differences in the Tapeats cross beds and later discovered (at Bijou Creek) that flooding bedforms can be "similar to the type commonly ascribed to intermittent accumulation" (McKee et al., 1967, p. 850).

Scour and fill and trough cross bedding are now seen as two different bedforms. Figure 18 shows both bedforms in a block diagram. While perpendicular to flow, scour shows tangential contact of the leading edge of each foreset and occurs en echelon when viewed parallel to flow. Cut and fill, by contrast, exhibits primarily parallel bedding planes, parallel to flow and with the likelihood of tangential contact along the edges of the cut channel only. Additionally, larger clasts may be found along the bottom edges of the cut channel, where they were left as lag from the scouring process having been moved as bed load.

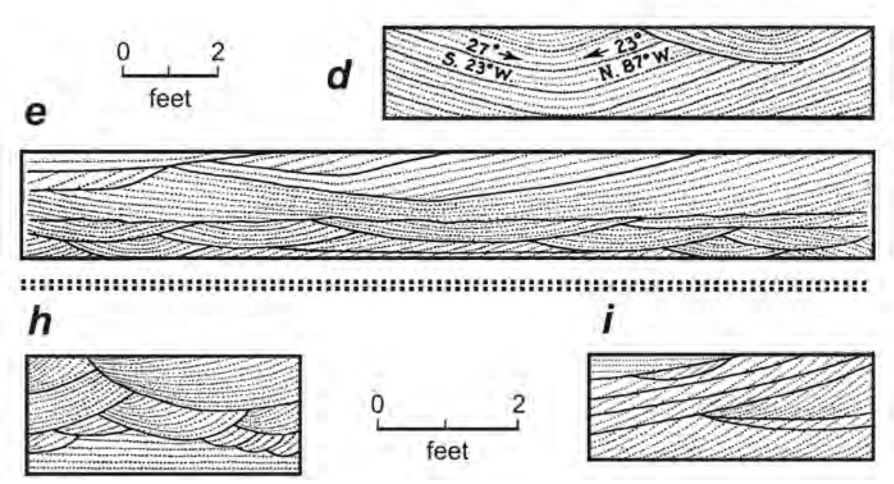


Figure 17. Lamination patterns in Tapeats Sandstone beds. From figure 5 in McKee (1945). d = East fork, Pipe Creek; e = East of Pipe Creek; h = Near Yaki [now South Kaibab] trail; i = West Fork, Pipe Creek.

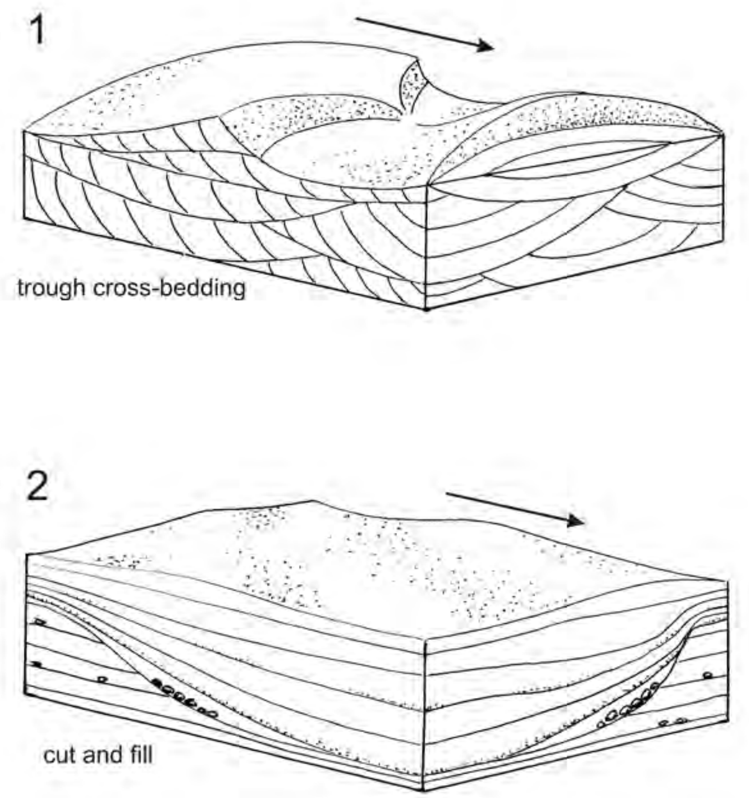


Figure 18. Block diagram. (1) Trough cross bedding (after Nichols, 1999, his figure 4.11); (2) cut and fill bedding.

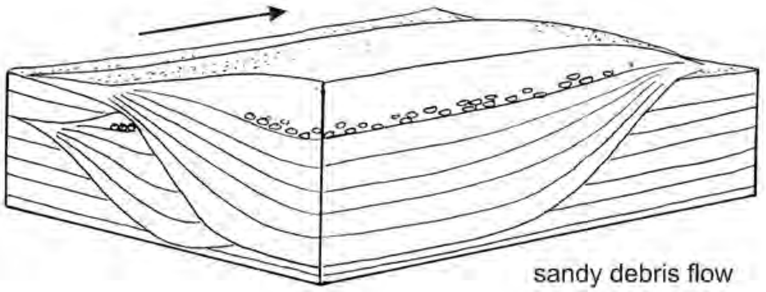


Figure 19. Block diagram of sandy debris flow deposits.

Sandy debris flow (Figure 19), by contrast, will show parallel bedding planes both perpendicular and parallel to flow, with larger clasts suspended at the top of the deposits where they were carried, rafted on the top of the hyperconcentrated laminar bedforms. Additionally, debris flow will show characteristics of sediment layers typical of plastic flow, while scour and fill or trough cross bedding may be plastic or fluidal.

The cross bedding perpendicular to flow in a sandy debris flow shows the bottom layer to lie perfectly cupped in the eroded channel. This is too accurate a fit to have been accomplished by one wave or current eroding the scour and a separate current with a slightly varied direction of flow depositing the first layer. Figure 20 shows dunes, even 3D dunes, are consistently deposited at a lower velocity for all grain sizes than high-velocity flat beds. If the flat beds show characteristics of deposition by high-velocity currents, as I have shown the lower Tapeats to be, then dune formation, according to Figure 20, would indicate a sharp decrease in velocity that would not erode down into a bed laid at a higher velocity.

McKee (1945, p. 41) noted a "considerable contrast in the average grain size of adjoining laminae." This implies the layers are discernible by grain size, but a careful look at Figure 21, the deposit with the clearest image of these features, shows that the layers are not as clearly discernable as those often seen in cross bedding. Instead, they are reminiscent of hyperconcentrated laminar bedforms from flood flows in the debris fields of Mount St. Helens (Figure 9) or those at Bijou Creek. The small flow of Figure 21.1, located along the Kaibab Trail (Figure 7), corresponds to McKee's (1945) figure 17h. The top exhibits "outsized rafted clasts." That is a characteristic of debris flows (Figure 5.1), but these are no larger than small pebbles and coarse sand. However, in this case that is likely a factor of sediment source rather than velocity. These clasts were the largest available of the entrained sediments and dispersive shear pushed them to the top (Figure 5.2).

Trough cross bedding typically forms in fluidal conditions, where turbulence keeps particles in suspension that settle out at a constant rate while the flow

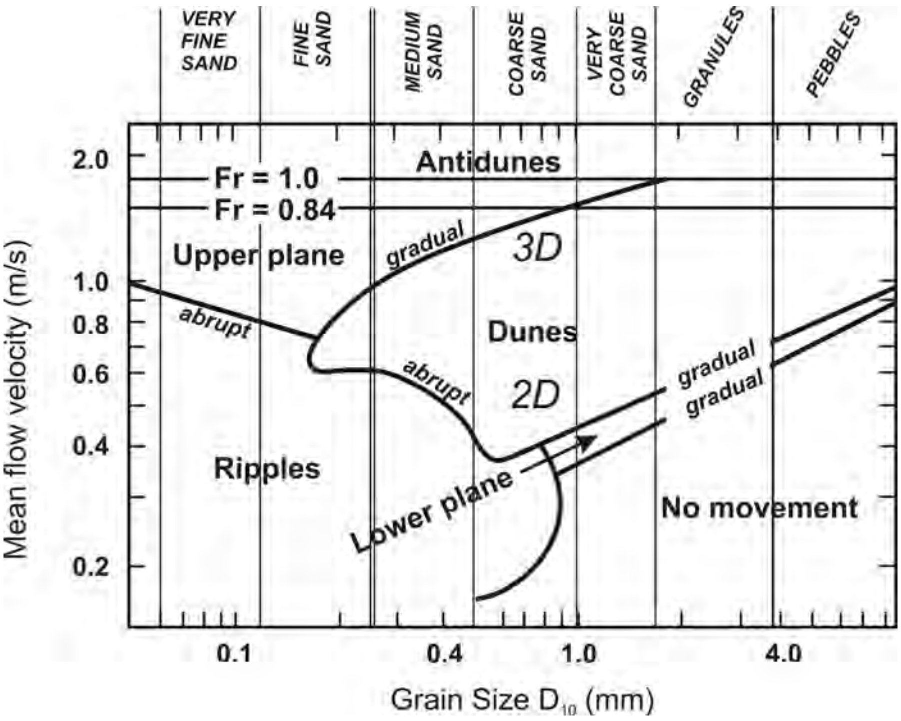


Figure 20. Bedform stability fields by grain size divisions, showing the bedform progression for velocity increase and decrease. After figure 5.15 in McLane (1995).

moves the bedload. They are deposited grain by grain as they cascade down the lee slope of a dune (Julien et al., 1994). In contrast, the Tapeats layers here appear to have been deposited under plastic flow conditions.

Figure 22 is a sketch made from the photograph of a very thick volcanic debris-flow conglomerate in the Laguna Goth section of the Cretaceous Cerro Toro Formation in southern Chile (Sohn et al., 2002). It, too, shows incision into flat beds, irregular discontinuous layers of sediment parallel to the erosional surface, erratic wandering of the current eroding into previously deposited materials, and a coarse sediment cap in the central area of each individual flow. These are similar to features of the "trough cross bedding" or "scour and fill" found in the Tapeats. Since the Cerro Toro deposits are considered debris flow sediments, then these similarities suggest the same origin for these deposits in the basal Tapeats.

Shanmugam (1996, p. 2) classified a debris flow composed primarily of sand as a "sandy debris flow," and he would use the term to replace "high-concentration turbidity flows" and "mass flows" commonly seen in the literature because the plastic flows do not involve flow turbulence in the depositional layer. He cited Dott's (1963) definition of a mass flow as being most descriptive:

> (1) A "non-Newtonian flow that exhibits plastic behavior." (2) High concentrations of sediment supported by "dispersive pressure (caused by grain collision), hindered settling, and buoyant lift (caused by mixture of water and fine grains) (modified by Postma et al., 1988)." (3) "Deposition from these flows occurs by 'freezing'" (Shanmugam, 1996, p. 7).

While Shanmugam (1996) provided no cross-sectional diagram of a sandy debris flow, Figures 5.1 and 5.2 are based on his figures of a "high-density turbidity current" deposit with larger clast sizes.

Furthermore, the "trough cross beds" in the Tapeats never pinch out to form tangential foresets at either end. What appear at first glance as tangential ends are in fact erosion surfaces cut by an erratically wandering current. Sedimentary layers are produced by laminar flow at the bottom of the high-concentration turbidity current (Figure 8.2), leaving irregular alternations of coarse and fine sediments as predicted by Figure 5.2. These are frozen as one body when the shear stress declines sufficiently. Each new trough in the stack begins with a new tongue of the flow preceded by its own "flow front [that] can be repetitively detached and diluted to form voluminous turbidity currents. The turbidity currents outpace or are outrun by the debris flows resulting in extensive turbidites beneath and above the parental debris flow deposits" (Sohn, 2000, brackets added). While I would side with Shanmugam (1996) in not using the term "turbidites," Sohn (2000) and Sohn et al. (2002) are still referring to the same bedforms that originate from a sandy debris flow. Within a debris flow current, there would be multiple tongues, some with their own turbulent head. These would erode into previous deposits and leave multiple layers of sediment, some with laminar flow layers and some with irregular discontinuous layers. The sedimentation style would depend on the extent of dilution of the debris flow at the time of deposition, but each of the layers deposited behind the turbulent head will be laid down roughly parallel to the original eroded channel surface (Figure 19).

Figure 16 shows the lowest occurrence of a sandy debris flow, immediately overlying the Great Unconformity. It matches the pattern of McKee's (1945) figure 17d, located on the east fork of

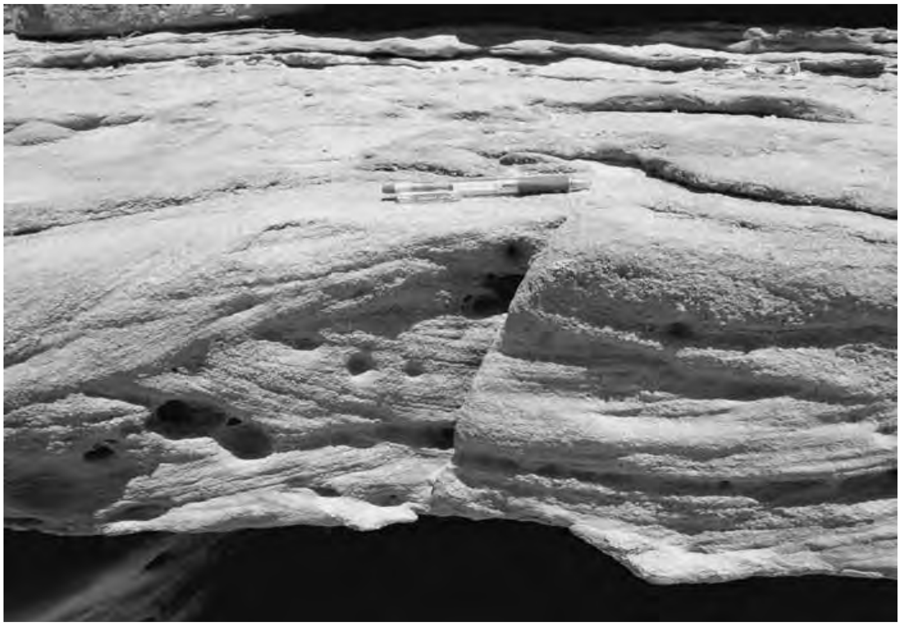


Figure 21.1. Trough cross bedding in Tapeats Sandstone, South Kaibab Trail (Yaki Trail of McKee, 1945). Photo from Oard (2010).

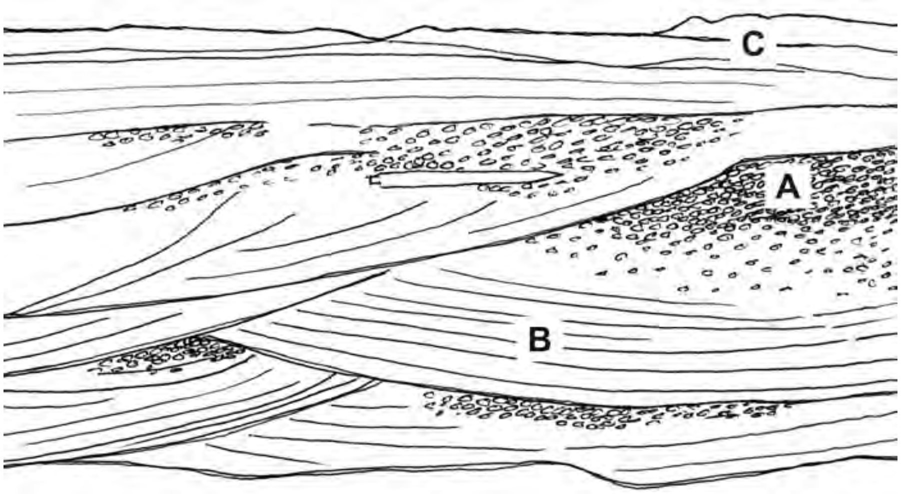


Figure 21.2. Sketch showing (A) disorganized outsized rafted clasts of coarse sand, (B) general trend of trough cross bedding, and (C) hyperconcentrated laminar bedform.

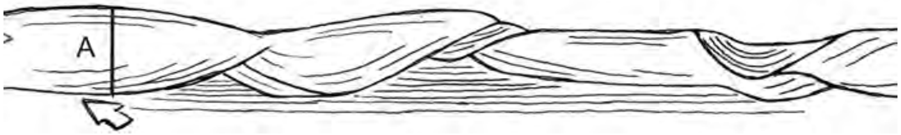


Figure 22. Sketch of trough cross bedding in Laguna Goth section of volcanic debris flow, taken from a photo. Paleoflow direction is to the left and obliquely into the page (arrow, lower left). Scale is about 8 m at A. Based on figure 4 in Sohn et al. (2002).

Pipe Creek (Figure 7). This occurrence is the only example in this study where a debris flow did not erode underlying high-velocity flat beds or it eroded them all the way down to the crystalline basement. It is composed of mature, well-sorted fine sand. Lowe (1982) recognized the traction layer (his layer S) as the lowest division of a sandy debris flow (Figure 5.2). The flat beds of breccia, visible above the sandy debris flow of Figure 16, show that either the cascading of breccia down paleotopographic highs was a recurring event or that the debris flow occurred during such a cascade. Conglomeratic high-velocity flat beds directly above high-velocity flat beds illustrate the debris flow was part of a larger energetic event, not an isolated energy pulse.

If the majority of the basal Tapeats is formed of hyperconcentrated laminar layers, irregularly interrupted by interspersed debris flows (apparently associated with monadnocks), then this mechanism of cascading clasts off monadnocks may account for the infrequent gravity flows. Flat beds of breccia in the background of Figure 16.1 support this mechanism as the energy source behind the debris flow as it descended and pushed the previously settled sand ahead of it as a plastic flow. Both Scott et al (1995) and Smith (1987) cite sidewall failures in volcaniclastics that were previously in stable equilibrium as the most common source of gravity flows off areas of volcanic debris.

Figure 11 shows a thick section of sandy debris flow that matches the pattern of McKee's (1945), figure 17e, east of Pipe Creek (Figure 7). The photo was labeled "Peach Springs Canyon," and the location is uncertain. It shows angular foresets, bounded below and above, by hyperconcentrated laminar bedforms. This arrangement is also seen in Figures 3 and 4. Bedforms comprised of a mixture of purple and white sand (Figure 10) also suggest that the debris flow was just a part of a more extensive high-velocity flooding event. Combined with the high-velocity flat beds of Figure 16, we see that all the layers of the basal Tapeats were deposited during a continuing unidirectional current covering a large area.

Chadwick and Kennedy (2001) provided one photo and measurement of what is possibly the largest breccia deposit yet documented alongside a monadnock. Found in 91 Mile Canyon (Figure 7):

> The breccia underlies most of the Tapeats Sandstone as well as 112' of Bright Angel Shale along the Precambrian slope. Breccia extends for vertical distances of up to 140 meters and horizontally up to 2 kilometers from the Shinumo outcrops … exhibiting no evidence of post-depositional erosion or reworking prior to burial. The breccia persists up-section, along the Precambrian contact, in some cases underlying the entire thickness of the Tapeats Sandstone and portions of the Bright Angel Shale. (Chadwick and Kennedy, 2001, p. 3)

The height of this breccia slide is Chadwick and Kennedy's (2001) primary evidence for their proposed water depth of > 200 m. Their use of the phrase, "in some cases," suggests that some intertonguing of the breccia flow may occur with the Tapeats or Bright Angel and would thus make 91 Mile Canyon a very profitable research location to document the specific interactions of the Tapeats, Bright Angel, and breccia to help determine the energy profile of the depositing event.

Rose (2006) documented another debris field of breccia in the vicinity of Zoroaster Canyon (Figure 7). The debris flow sediments persist up to the transition zone between the Tapeats Sandstone and the Bright Angel Shale. Boulders of Precambrian Zoroaster Granite lay next to a monadnock of the same composition. This is the largest breccia deposit documented at this stratigraphic level, and does not appear to be connected with stratigraphically lower flows. However, it does shed light on the energy of events throughout Tapeats deposition; the entire formation may well be the product of a single event, not different events separated by long periods of time. It may also suggest increasing energy conditions persisting even near the end of sandstone deposition and the transition to clay and mudstone in the shale above. If so, it would be contrary to most interpretations of the transition from the Tapeats to the Bright Angel.

Discussion

Sedimentology

Contrary to the proposed facies models of most geologists, this sedimentological analysis of the basal Tapeats demonstrates deposition by energetic events, leading to debris flows, breccia cascades, and hyperconcentrated laminar bedforms. Whether such events represent the regressive current that might have eroded the Great Unconformity in its transgressive phase, as Berthault (2004) described, it is unlikely that the unconformity surface was exposed for any significant time period as a subariel surface. Weathering, identified by Sharp (1940), was used by others (McKee,1945, Hereford, 1977, Rose, 2006) to posit an extended period of exposure for the unconformity prior to the start of sandstone deposition. Up to 1.2 Ga (Karlstrom et al., 2003) is supposed to be represented by the contact between the Vishnu Schist and the Tapeats.

This "weathering" was recently attributed by Rose (2006) to redox processes. While some occurrences of this bleaching are restricted to surfaces below the unconformity, like the Hakatai Shale (Figure 23) below the erosion surface on the monadnock, and might have been produced by chemical weathering while exposed during the 1.2 Ga hiatus, other locations, such as one along the Clear Creek Trail (Figure 4), show bleaching

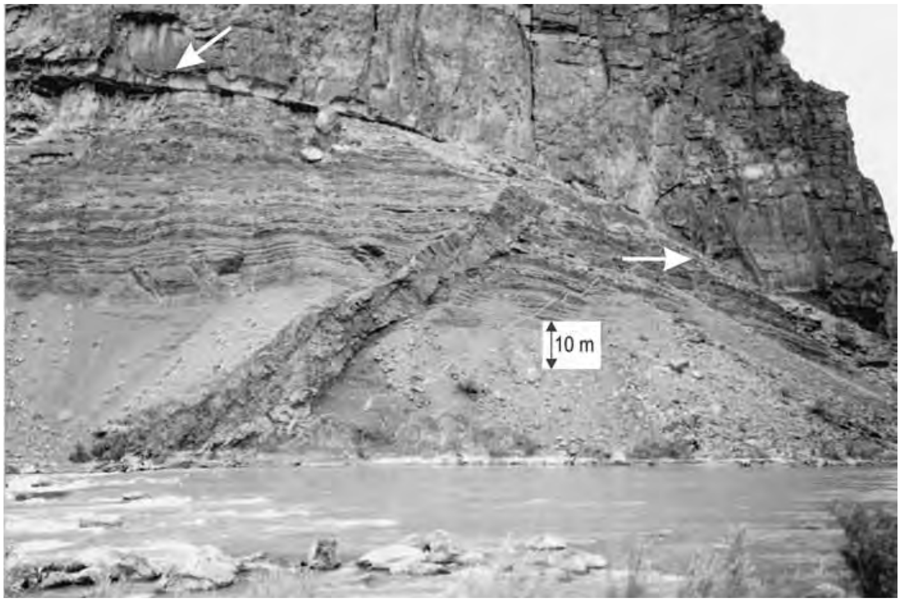


Figure 23. Great Unconformity in Garnet area with a Precambrian high of liver-red Hakatai Shale cut by a basalt dike. Tapeats Sandstone on right abuts Hakatai without any "run up" (lower arrow). Bleaching occurs on upper ridge of Hakatai from dike to the top of the high (upper arrow). Distance from river to the bottom of the dike, at its upper end, is about 10 m.

extending up from the Vishnu Schist into the sandstone. Rose (2006) thought that oxidizing pore fluids in the Bright Angel Shale produced similar results. If bleaching in the Bright Angel was the result of diagenesis, then it is reasonable to suspect that might also be the case in the Tapeats. Figure 4 shows a cavity that seems to be the locus of bleaching that spread outward across the unconformity. The bleaching extends an equal distance in all directions, even across the supposed 1.2 Ga unconformity (Barnhart, 2011a). This juxtaposition of ripple bedforms, sandstone deposition, and bleaching shows that these were not events separated by millions of years. If so, the time thought to be present in the unconformity surface as well as that thought necessary to produce the "facies" of the Tapeats may not be necessary to explain the field evidence.

Another "evidence" for extreme age is the use of the term "regolith" for the breccia deposits in the basal Tapeats.

> Distinction between sedimentary source and basin are obscured in low-relief, low-slope cratonic interiors; the bulk of sedimentary cover in such settings must therefore be seen as resident regolith. (Rose, 2006, p. 234).

This conclusion rests mainly on the assumption of long periods of time, not field evidence. As such, the conclusion is circular. The presence or absence of weathering in the basal Tapeats or along its subcrop is something to be demonstrated. The breccia clasts do not appear weathered. They are not a part of a paleosol (Klevberg et al., 2009), as would be expected if subaerially exposed, and there are few, if any, attached invertebrates to suggest an ancient beach. The petrology and position of the cobbles and boulders indicate an origin atop adjacent elevations, suggesting only that they were broken or eroded from those highs, and then tumbled downhill under the influence of the current and/or waves that deposited the basal Tapeats.

Rose (2006, p. 228) described the Great Unconformity in the eastern Grand Canyon, where the monadnocks occur, as a "peneplain with only local relief in excess of a few meters per 100 meters laterally." So other than occasional monadnocks—including one that reached 140 m above the surrounding surface at 91 Mile Canyon (Chadwick and Kennedy, 2001)—any violent transgression across the areas would have met comparatively little topographic resistance.

The Tapeats Sandstone has long been interpreted within the framework of uniformitarianism. As far back as 1795, James Hutton proclaimed, "The past history of our globe must be explained by what can be seen to be happening now.... No powers are to be employed that are not natural to the globe, no action to be admitted except those of which we know the principle" (Hutton, 1795, cited in Holmes, 1965, p. 43).

Three conditions are stipulated here, and for a mechanism of erosion or sedimentation to be acceptable it needs to satisfy all three of them.

1. "Can be seen to be happening now." While this point is often viewed by most casual observers as the most important, it does not stand alone. Hutton tied it to the following two conditions.
2. "Power must be natural." But this also implies the power must be adequate. McKee's (1967, p. 850, brackets added) statement relates here: flood sediments (high energy) are very "similar to the type commonly ascribed to intermittent accumulation in quiet water [low energy] over a long period." There is a large difference between low energy operating over a long time and high energy over a short time. There are "natural" conditions for both possibilities.
3. "Know the principles." The principles of erosion and sedimentation are becoming better defined empirically, but geologists must be certain that they understand and apply them in proportion to the power exhibited in the nuances of the bedform. This is where the facies model approach fails. While a given modern environment may satisfy some observations and appear to be a shortcut to a fuller understanding of others, a more careful observation and measurement of those conditions may show power and principles outside the possibilities of that facies.

The Flood is often viewed as a cause for erosion and sedimentation outside what "can be seen to be happening now" and therefore violates Hutton's first condition. It is a mistake to view the Flood as a giant facies model; that approach has proven much less profitable than hydrodynamics. Though the Flood was outside of modern experience, flooding is a regular, observed occurrence, and its principles are increasingly well understood through the discipline of fluid dynamics, which applies to a variety of media over a variety of scales, from micrometers to kilometers (Marusic et al., 2010; Rubin and McCulloch, 1980). Therefore, with more complete understanding of these physical principles, explanatory solutions to *geological* mechanisms of erosion and sedimentation at appropriate scale may be achievable.

McKee (1945) tried to satisfy the first of Hutton's points by proposing a long, slow transgression to account for the Tapeats exposures. He limited the portion involved at any one time by positing the slow continual advance of the shoreline. The areal extent of the Tapeats is still problematic, given the scale of modern marine incursions. To account for this, Rose (2006) made much of the differences between the Tapeats associated with the monadnocks in the eastern canyon and that covering the level peneplain in the western canyon. He emphasized that no actual bedding plane or fossil assemblage can be physically traced from the western to the eastern exposure. Despite the implication, he never came out and said that the Tapeats is not a continuous formation.

Hereford (1977) traced the formation an additional 230 km south to near Payson (Figure 7). In central Arizona, Hereford (1977) located monadnocks in the areas of St. Matthews, Hickey Mountain, northwest of Cherry, and west of the Big Black Mesa. He correlates his facies C, in central Arizona, with McKee's (1945) descriptions of the Tapeats in the Bright Angel Creek area (the area of monadnocks and sandy debris flows). Hereford's noting monadnocks running north to south emphasizes the similarities of the Tapeats subcrop and by implication the Tapeats deposition. Using these authors' descriptions to draw a rough triangle, the minimum area of the Tapeats is about 23,000 km^2. To account for this large area, Hereford (1977) split the Tapeats into six facies—from onshore to shoreline to offshore. Hereford (1977, p. 204) pointed out, "Sedimentary structures in faces C … are common in modern beach environments." And, his model "assumes that in the western half of central Arizona the Tapeats Sandstone was deposited primarily on sandy intertidal flats where the rise and fall of the tides molded the coarse sediments into many different forms" (Hereford, 1977, p. 209). But he would have done well to heed McKee et al.'s (1967, p. 850) caution: "Much of the layering is in the form of fine laminae similar to the type commonly ascribed to intermittent accumulation in quiet water over a long period of time."

Hutton's first point is largely rejected by geologists today. The Tapeats simply adds another reason. Does attributing the basal Tapeats to debris and hyperconcentrated flows find modern analogs, things that "can be seen to be happening now"? It certainly does help us identify an "action … of which we know the principle." I have correlated Tapeats bedforms with those from flooding associated with volcanism. But they do not approach the size of the Tapeats. What are the most common occurrences of these flows today?

The most cited occurrences for debris and hyperconcentrated flows are in overbank splay deposits and alluvial fan deposits (Smith, 1986), fluvial fan deposits, and proximal submarine fans with subaqueous sediment gravity flows (Balance, 1984). Smith (1986) recognized that any such flows deposited by fluvial processes are seldom more than 10 km in radius, while volcanic "debris flows may extend 100 km or more from their sources … and combined with high-sediment loads, may construct aprons of coarse volcaniclastics debris covering hundreds of square kilometers" (Smith, 1986, p. 1). If we are seeking a modern analog, the volcanic model seems the only one that could possibly result in a deposit the size of the Tapeats.

Subaqueous gravity flows down canyons do cover large areas of the ocean floor, but these are not good analogs for the Tapeats. The erosion surface of the Great Unconformity is a peneplain projected to extend many hundreds of km, both to the northeast, the direction of the sediment source, and the west, the direction of transport (Rose, 2006). It provides no elevation or erosional features at its perimeter high enough or large enough to produce such a gravity flow that is comparable to canyons off the edge of today's continental shelf.

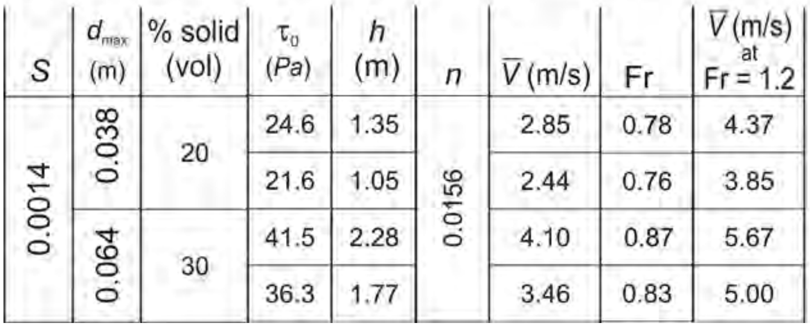
What about storms and hurricanes? Unfortunately, they do not generate plastic flows that deposit sediments exceeding 10 m in thickness. This paper has documented those kinds of flooding events to have occurred from the start of deposition (Figures 3 and 16) and to continue well up in the deposits (Figures 11 and 12). It is possible that these various layers represent multiple storm events, but the layers in between, like those in Hurricane Katrina splay deposits (Barnhart, 2011b, his figure 5), show no visible break with layers at the top genetically connected to layers at the bottom (Figure 13). This connection through the middle and upper Tapeats will be the thrust of the final paper in this series. All evidence seen here requires a continuously depositing, essentially unidirectional current during the entire period of deposition. Furthermore, no modern beaches or estuaries cover the area of the Tapeats. Comparisons of this sort are speculative and not well supported by evidence. Attributing the differences to the lack of vegetation (another uniformitarian speculation) per Hereford (1977) or an expansive epicratonic estuary (Rose, 2006) is simply an admission that the Tapeats is not like modern deposits and thus, like so many other features of the rock record, runs counter to Hutton's dictum.

Hydrodynamics

How reasonable are the velocities as calculated in Tables I and II? Costa (1987) correlated data on the twelve largest flash floods in small basins—0.39 to 368 km^2—much smaller than the Tapeats depositional area. Costa's (1987) work showed velocities of 3.47 m/s to 9.92 m/s. These are significantly higher than those in Tables I and II. While slopes on Costa's flood surfaces varied from 0.000286 to 0.0964, his correlation between slope and velocity was weak. Froude numbers varied from 0.81 to 2.49. Like velocity, his Froude numbers did not correlate well to slope; the lowest Froude numbers do occur with the lowest slope ratio.

Costa's (1987) relationships between different parameters suggest some value in varying those in Tables I and II to see how velocity varies (Table V). A flow depth of 1.05 m was obtained for the 10:1 ratio of flow depth to bedform height. Equation (2) thus yields a slope of 0.0014, a value well within the pos-

Table V. Revised Velocities
Calculations based on lower slopes and increased flow depth (h).
Set of velocities obtained by increasing Froude number to 1.2



S	d_{max} (m)	% solid (vol)	τ_0 (Pa)	h (m)	n	$\bar{V}$ (m/s)	Fr	$\bar{V}$ (m/s) at Fr = 1.2
0.0014	0.038	20	24.6	1.35	0.0156	2.85	0.78	4.37
			21.6	1.05		2.44	0.76	3.85
	0.064	30	41.5	2.28		4.10	0.87	5.67
			36.3	1.77		3.46	0.83	5.00

sible Tapeats subcrop. Using this slope, Equation (2) yields flow depths ranging from 1.05 to 2.28 m. Using the Manning equation (3), velocities of 2.44 to 4.10 m/s were obtained. These values are within the range of answers produced by varying parameters and thus not of great significance, and the resulting Froude numbers fell significantly, ranging from 0.76 to 0.87, contrary to the desired result. These are low values for flood conditions (Barnhart, 2011b; Costa, 1987).

Another way of evaluating velocity was to substitute a Froude number of 1.2 into Equation (4). The flow depth was derived using $S = 0.0014$, and the equation was solved for velocity. This Fr was only slightly elevated but matched Costa's (1987) lower Froude number with the same slope. A higher value than Fr = 1.2 is hard to justify. However, the resulting velocity was 3.85 to 5.67 m/s (Table V), which are only 35% to 57% larger than the originals. Even so, these are still not as great as those seen in some of Costa's (1987) small flash flood events.

Costa (1987) correlated his lowest velocities with the lowest slopes, and the lowest Froude numbers did correspond with the lowest slopes. The lower velocities of Tables I and II suggest then that the paleoslope of the Tapeats subcrop was very low. But since plastic flows primarily acquire energy from gravity, movement over a slope of 0.0014, equivalent to 0.09%, would be very difficult to sustain over distances of 10's of meters, much less 10's of km. One way around this problem is the existence of a large, ongoing energy head behind the current, forcing the longer transport distances. Barnhart (2011b) pointed out the strong current in the London Avenue neighborhood of New Orleans was dependent not only on the hurricane but also on the size and height of Lake Pontchartrain; this large body of water was pushing through the levee breach. What was the "Lake Pontchartrain" for the Tapeats? It seems logical that it was located to the northeast, the direction of the sediment source. This is exactly the opposite direction that is offered by McKee (1945), Hereford (1977), and Rose (2006) for the transgressing ocean basin, but it needs to be considered.

Conclusion

We understand much about beaches today, from estuaries to below wave base we have seen how sediments are eroded, transported, and deposited. Bedforms and their causal conditions have been documented. A broad range of observational data is available for comparison to the basal Tapeats. If this sandstone represents a beach environment, then we must assume that the sand was deposited one wave at a time and that it was worked and reworked into its preserved bedforms. That would satisfy Hutton's first requirement.

But the paleoenvironmental option does not explain the observed sediments and bedforms of the formation. Instead, the basal Tapeats was deposited quite rapidly—between 9 and 54 m/hr, and by a plastic flow reflecting flood-flow conditions. Rose's (2006) suggestion of estuarine deposition seems plausible on the surface, but it would require a river with a depositional front of about 300 km, the distance from Grand Canyon's western mouth to the southern end of the Tapeats in central Arizona (Figure 2). This would be a river as wide as Baja, California and the Gulf of California combined! Clearly, no such river exists anywhere on Earth today, and Hutton's principle is invalidated.

Additionally, for a river to produce the necessary hyperpycnal flow, it would require a depth-averaged flow velocity of 3 m/s over a significant distance from the point of submerging up to 10's of km. Furthermore, it would have required a velocity of 15 m/s or more (Lamb et al., 2010) for the flow prior to the plunge point. Such a velocity would require a slope of 0.05 – 0.10 or higher. Yet the slope for the basal Tapeats was determined to be lower than $S = 0.016$ and probably in the range of 0.0025, two orders of magnitude less. Nor does that kind of flow fit with Rose's (2006, p. 234) description of "tidal channels [that] meandered and temporarily pooled and flowed."

Moreover, the erosion and deposition cycle of a beach and its associated areas suggests an ongoing process over long periods of time. But the Great Unconformity is a surface created abruptly, exhibiting only a few meters of erosional breccia in only a few isolated locations where bedforms were deposited in seconds to minutes under flood-flow conditions in a one-time event. Outside of these few isolated locations, covering a total area of less than a km^2, the overwhelming majority of the 23,000 km^2 of the Great Unconformity shows abrupt erosion, creating a planation surface with low relief—variations of less than "a few meters per 100 m laterally" (Rose, 2006, p. 228)—and showing no erosional transition over the vast majority of that surface. Nowhere do geologists find the expected thick weathered surface. The Great Unconformity, therefore, also invalidates Hutton's dictum.

The evidence of weathering put forth by Sharp (1940) and vetted by McKee (1945) is better explained by chemical changes after burial; diagenesis in the Precambrian rocks continued as the Great Unconformity was eroded and into the deposition of the basal Tapeats (Barnhart, 2011a).

Many authors have called the breccia on the sides of monadnocks "regolith," implying a long period of weathering. But this has been shown to be a biased assumption not supported by actual field evidence. Once again, the facies model approach is shown to be camouflage for uniformitarianism.

Secular geologists have been blinded by the perceived presence of long periods of time for Earth's past. They "know" that the Tapeats must have been deposited over a long period of time and posit low energy sources as causes. However, the size and scope of the catastrophic forces required to deposit these layers can be determined by quantitative sedimentology, and these suggest a more complex origin than the facies-models approach. In the second paper of this series, it will be seen that the middle and upper Tapeats render the problem even more complicated. Regardless, it is clear that the Tapeats was deposited over a freshly eroded surface rapidly enough to "freeze" breccia cascades off of topographic highs. This was accomplished by a strong, unidirectional current with superimposed storm surge waves. Thus the Tapeats is easily interpreted within the constraints of the Genesis Flood but less easily so by uniformitarian or actualistic models.

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To the two angels, Sandia and John, without whose help and encouragement this paper would never have come to be, and to the reviewer whose questions stimulated additional thought, I express my deepest thanks. You were each truly ministering spirits (Hebrews 1:14). May the Lord "establish the work of our hands for us—yes, establish the work of our hands" (Psalm 90:17, NIV).

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Racism Taught in Biology Textbooks for Decades

Jerry Bergman*

Abstract

Textbooks are a major means of imparting not just facts, but also beliefs. One concept often included in books supporting Darwinism published before 1960 was the belief that there exist "Caucasian" and "Negroid" races, now commonly called the "white" and "black" races. The view that whites were "superior," and blacks "inferior" and more "apelike" was commonly taught in science texts and even scholarly academic books published in the Western world from the middle 1800s to around 1960, and a few after this date. A few typical examples were examined to illustrate how racism was once taught. This paper compares textbooks used in America and Nazi Germany, documenting the fact that their coverage of evolution and eugenic topics was similar. Although all of the examples examined for this paper were published in the USA and Germany, most of these textbooks were translated into Spanish, French, and other languages and used throughout the world.

Introduction

Eugenics and racism were widely taught in school textbooks in America and Germany dating back to the very first book Darwin wrote on his theory. Darwin's racist views were unequivocally clear in his *The Descent of Man and Selection in Relation to Sex*. This 1871 work helps us to understand the meaning of the title of Darwin's most famous work, *The Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life*, often abbreviated to *The Origin of Species* (1859). As to Darwin's subtitle, *The Preservation of Favoured Races*, it is clear that he was concerned with races of animals, but "it is also clear … that he thought of races of men in the same way" (Morris, 1973, p. 158).

Textbooks were critical in the goal of Darwinizing society in both America and Nazi Germany. This is indicated by a statement attributed to Hitler: "Let me control the textbooks and I will control the state" (Klicka and Harris, 1992, p. 89). Hitler insured that Darwinism was taught in the textbooks for the reason that "Darwinian theory became important truths in Hitler's ideology" (Blackburn, 1985, p. 22). Furthermore, the Nazi government insured that not only all teachers and professors were Darwinists committed to "Hitler's racial doctrines" but also that all textbooks must be revised to conform to this goal (Shirer, 1960, p. 249). The educators insured that the Nazi conception of the certainty of the "Darwinian struggle for existence ... a battle ... waged without end" was openly reflected in the textbooks (Blackburn, 1985, pp. 21–22). German educators, though, were forced to refine "Hitler's crude militaristic and social Darwinist ideas and made them somewhat more palatable to the educated" (Blackburn, 1985, p. 127).

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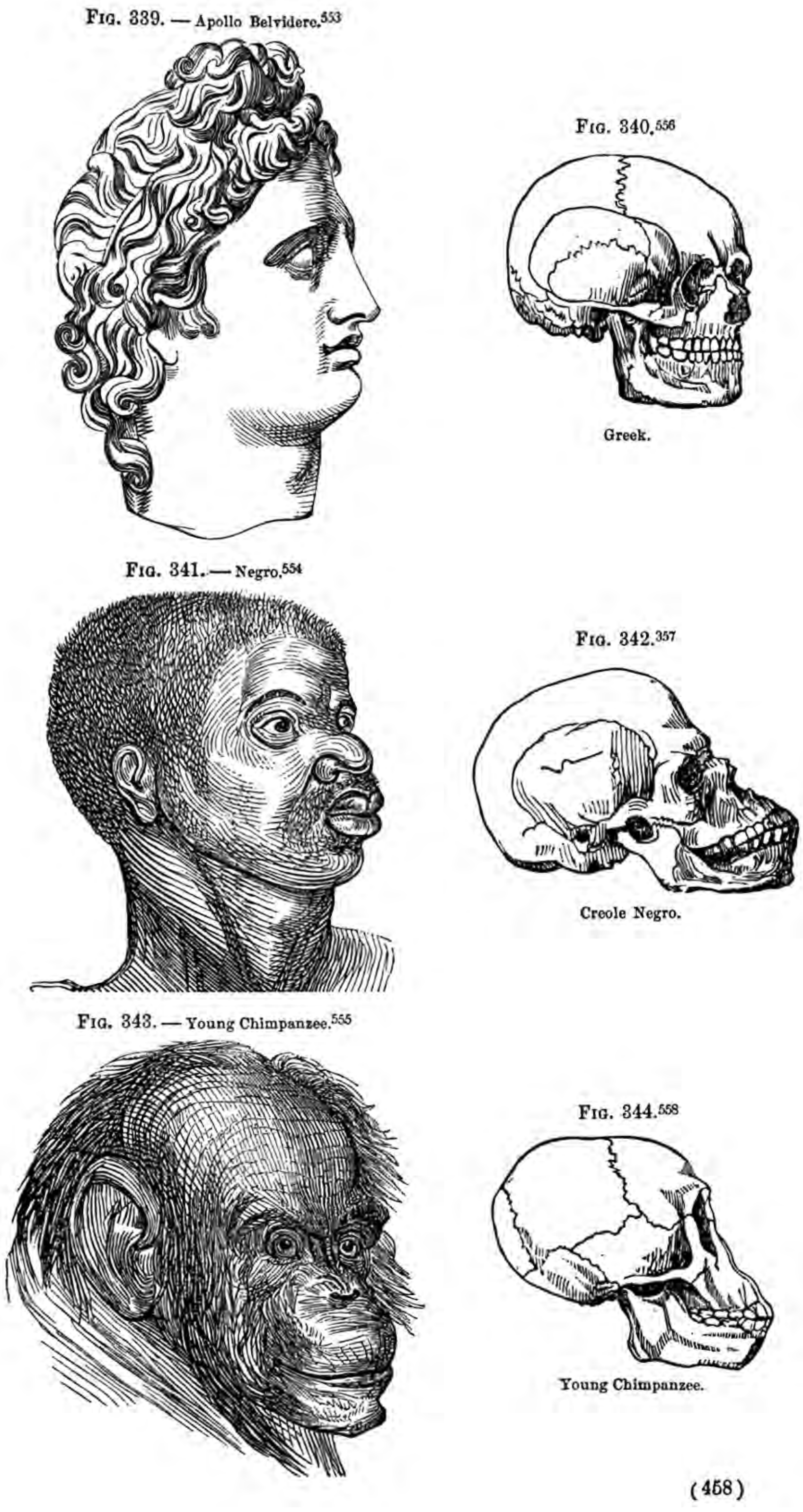


Figure 1. Illustrations of the highest evolved men, the Greeks, and the primitive ape-men, the "negro" compared to the ape. Note the Creole Negro skull is far more apelike than the modern man skull. Adapted from Morton (1854, p. 458).

Darwinism Influences Racism in Textbooks

Many authors and professors have written articles and books advocating racism, and some have been far more racist than Darwin's own writings. For example, Count Arthur de Gobineau in his 1854 book (reprinted as late as 1966) argued that the "Aryans" were not only superior to all other races but also were primarily responsible for civilization's major advances (Burleigh and Wippermann, 1991, p. 28).

Gobineau (1966) even claimed that when Aryans (i.e., northern Europeans) intermarried with the racially inferior (especially Jews and Negroes), civilization declined. He claimed that the inferior "mixed races" that resulted rebelled against the ruling class, resulting in the fall of great nations. His work influenced primarily German and European racists, many of whom synthesized his ideas with those of Darwin, as well as Professors Fischer, Schemann, Woltmann, and others. In contrast, although Darwin devoted major sections of his 1871 work to ideas supporting human racism, Darwin was personally opposed to slavery and was concerned about reducing poverty.

Until Darwin published his 1871 book, his major focus was on the evolution of plants and small animals. Yet it was Darwin, not Gobineau, who had a major influence on the racist ideology that developed after both Darwin and Gobineau had died. One of the reasons for this was that Gobineau's work was largely ignored and appealed to only a "handful of reactionaries," whereas Darwin's writing "enjoyed massive success" and both widespread acceptance and influence (Burleigh and Wippermann, 1991, p. 28). Darwin wrote numerous books supporting evolution, many of which were bestsellers and are still in print today. The idea of a never-ending struggle for survival that was achieved only by the stronger individuals and races, including human races, legitimized racism and put it on a scientific

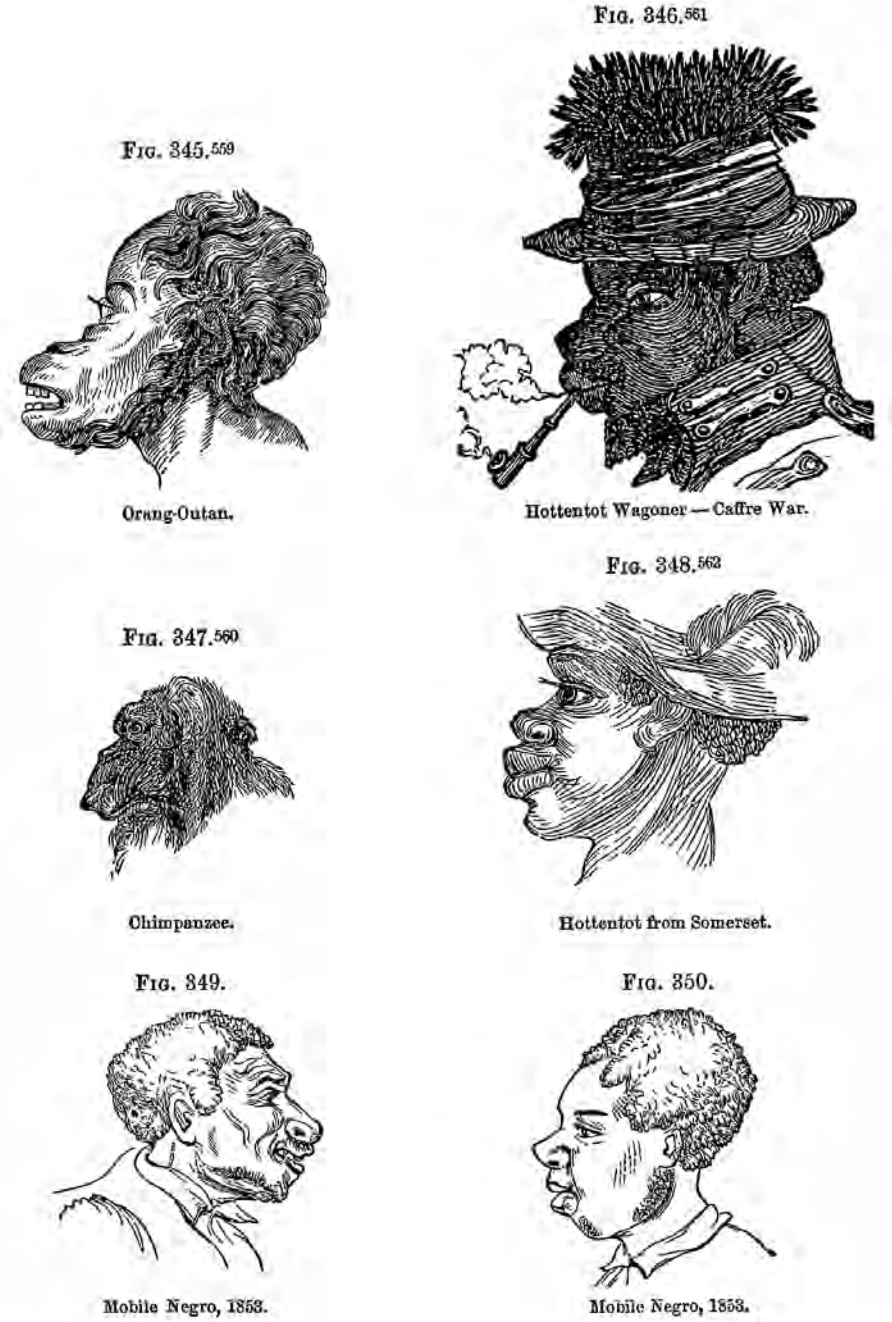


Fig. 345.559
Orang-Outan.
Fig. 346.561
Hottentot Wagoner — Caffre War.
Fig. 347.560
Chimpanzee.
Fig. 348.562
Hottentot from Somerset.
Fig. 349.
Mobile Negro, 1853.
Fig. 350.
Mobile Negro, 1853.

Figure 2. Comparisons of Negroes and apes. Note the similarity depicted between the Orang-Outan and the Hottentot Negro and the Chimpanzee and the Hottentot Negro. Adapted from Morton (1854, p. 459).

foundation propagated more by Darwin than any other person in history.

Darwin's influence through his writing was soon reflected in science textbooks, spreading what turned out to be catastrophic effects throughout the Western world. Larson (1989) concluded, "Public high schools were teaching evolution decades before the anti-evolution crusade [in the 1920s], with the presentation seeming to grow more dogmatically Darwinian over time" (Witham, 2002, p. 153, brackets added). Furthermore, school biology textbooks "presented Darwin's theory with great certainty, though field scientists still were fiercely debating its particulars" (Witham, 2002, p. 153). Even many nonbiology textbooks included racism. In a discussion of race, a leading nineteenth-century geography book concluded, "The White race is superior to all the others in intelligence and civilization" (Steinwehr and Brinton, 1881, p. 13).

A typical example of the racism once common in textbooks is the most widely used life-science textbook in America at the turn of the century, written by George Hunter and titled *A Civic Biology* (Witham, 2002, p. 153). Under the subtitle "The Races of Man," the text stated that there exists "five races or varieties of man, each very different from the other … to an extent, in structure." The five races were then ranked and at the inferior end was the Negro originating in Africa, "the Mongolian or yellow race, including the natives of China, Japan and the Eskimos; and finally, *the highest type of all*, the Caucasians, represented by the civilized white inhabitants of Europe and America" (Hunter, 1914, p. 196, emphasis added).

The text concluded that the Caucasians are "higher" developed specifically in terms of "instincts, social customs, and ... [physical] structure" (Hunter, 1914, p. 196, brackets added). This book also advocated the now-discredited eugenics theory for which Nazi Germany became infamous. Eugenics was taught under the subtopic "Improvement of Man." The text noted that domesticated animals can be improved, and, likewise, "the health and vigor of the future generations of men and women on the earth" can be "improved by applying to them the laws of selection," and concluded that in this "improvement of the future race ... we as individuals may play a part" (Hunter, 1914, p. 26).

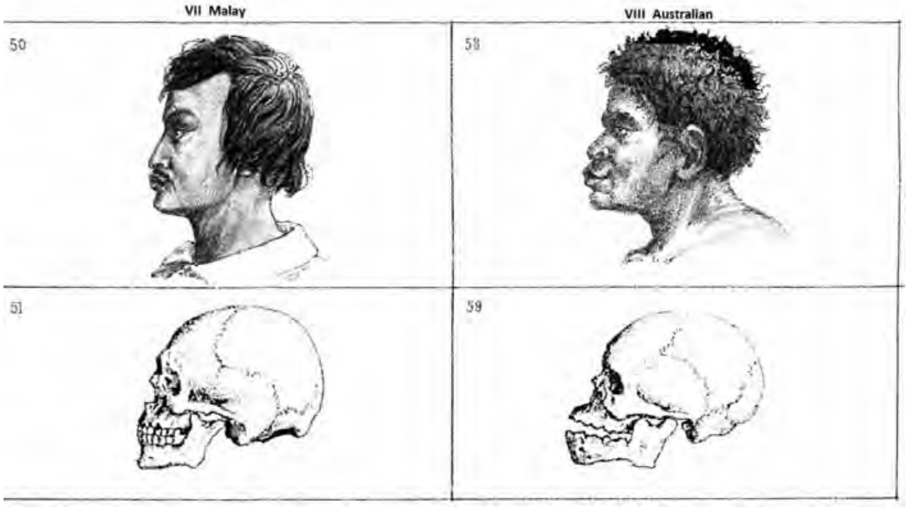


Figure 3. Malay and native Australian men profiles and their skull profile. Note how apelike the skulls are pictured. Adatped from Morton (1854, p. lxxvi).

Under the subtopic "eugenics," "the science of being well born," the text stated that when people marry "the individual as well as the race should demand … freedom … [from] germ diseases which might be handed down to the offspring. [and] ... epilepsy, and feeble-mindedness are handicaps which it is not only unfair but criminal to hand down to posterity" (Hunter, 1914, p. 261). Most of the diseases people were sterilized for by eugenicists for many reasons are not passed down to posterity, thus eugenic sterilizations ended up punishing innocent people for no valid reason.

This book, widely used in American public high schools for over thirty years, was the same textbook that John Scopes supposedly used as a substitute biology teacher when convicted of violating the law against teaching human evolution in public schools (Tontonoz, 2008). William J. Bryan recognized the nature of the book, thus his "overarching concern was the threat to society posed by extrapolations of evolutionary doctrine—namely social Darwinism and eugenics" (Tontonoz, 2008, p. 121). Contemporary evolutionists tend to ignore the blatant racial statements of this book when they commemorate the trial.

The example Hunter (1914, p. 261) used to prove eugenics is the infamous (and now completely discredited) Jukes' family history—which he calls a "notorious example" of a family "in which mental and moral defects were present in one or both of the original parents." The text claims that the mother of the Jukes' family was "the mother of criminals," whose progeny cost the state over a million dollars, "besides giving over to the care of prisons and asylums considerably over a hundred feebleminded, alcoholic, immoral, or criminal persons" (Hunter, 1914, pp. 261–262). To add weight to his argument, Hunter discusses yet another case, that of the Kallikak family, which has been traced to the marriage of Martin Kallikak and a "feeble-minded" woman. They had an alleged "feeble-minded" son whom the researchers counted had 480 descendants, of which 33 were labeled

> sexually immoral, 24 confirmed drunkards, 3 epileptics, and 143 *feeble-minded*. The man who started this terrible line of immorality and feeble-mindedness later married a normal Quaker girl. From this couple a line of 496 descendants have come [sic], with *no* cases of feeble-mindedness. The evidence and the morals speak for themselves! (Hunter, 1914, pp. 262–263)

From this dubious example, it appears that social factors and Kallikak's son's wife were the cause of the putative feeblemindedness, not Kallikak himself. Hunter claimed under the subheading "Parasitism and its Cost to Society," that hundreds of families like the Jukes exist today, "spreading disease, immorality, and crime to all parts of this country," and parasitic families "not only do harm to others by corrupting, stealing, or spreading disease…. They take from society, but they give nothing in return" (Hunter, 1914, p. 263).

Hunter then concluded that eugenics was the remedy to crime, poverty, and most other social problems, adding that if people like the Kallikaks:

> were lower animals, we would probably kill them off to prevent them from spreading. Humanity will not allow this, but we do have the remedy … preventing intermarriage and the possibilities of perpetuating such a low and degenerate race. Remedies of this sort have been tried successfully in Europe and are now meeting with success in this country. (Hunter, 1914, p. 263)

He concluded that eugenics has shown that "blood tells" inferiority (Hunter, 1914, p. 263).

Another widely used text in a chapter titled "Heredity, Eugenics, Euthenics: Some Family Histories," repeats the Kallikak and Jukes family histories but adds Jonathan Edwards's family as an example of "a superior family, the founder of which had sterling character and high mental ability" (Sanders, 1947, p. 435). This family produced a long line of doctors, professors, lawyers, authors, and other highly educated persons.

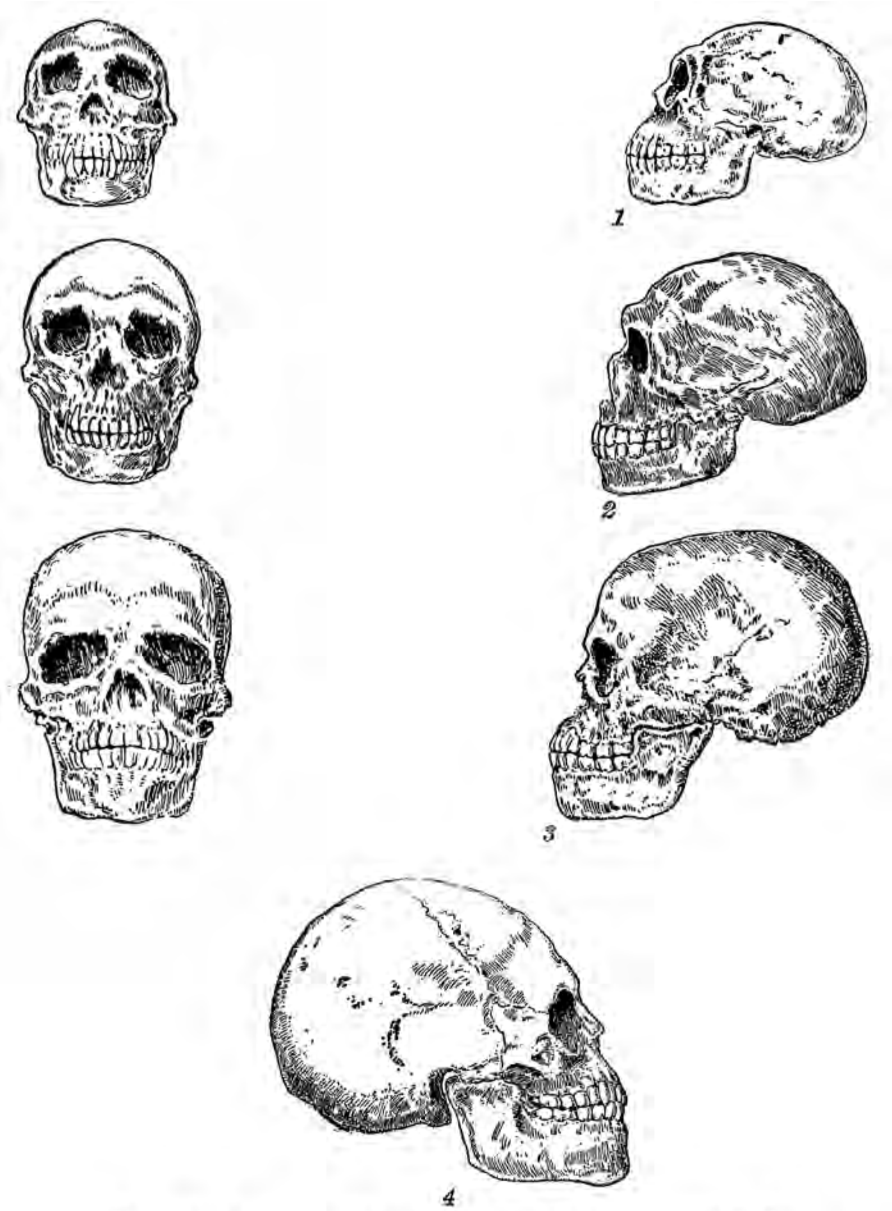


FIG. 256. Ancestors of man represented by remains of skulls

1, *Pithecanthropus erectus*, the "erect ape-man" of Java; 2, the Neanderthal man; 3, the negroid man of Laussel; 4, Nebraska glacial man. These four types represent successive advances in the evolution of the human races, although we must not think of them as a straight series of our ancestors. Compare the size of the brain at different stages of development: Pithecanthropus, 850 cc.; Piltdown, 1300 cc.; Neanderthal, 1600 cc.; modern man, 1500–1800 cc.

Figure 4. An early picture of the now disproven progression from apes to man. Figure 1 shows "Java Man," figure 2 Neanderthal man, figure 3 "Negroid man," and figure 4 "Nebraska man." The caption gives the brain size of Pithecanthropus as 850cc, Piltdown as 1300cc, Neanderthal as 1600cc and modern man as 1500–1800cc. Piltdown man has been proven to be a hoax and Neanderthal man and "Negroes" fully modern. Adapted from Gruenberg (1924, p. 493).

Some textbooks, such as *Evolution, Heredity and Eugenics* by University of Chicago professor John Coulter, were more tactful. This text noted that "destruction of the unfit" may be a more accurate summary of Darwinism than the more positive "survival of the fittest" (Coulter, 1916, p. 39).

A Half-Century of Indoctrination

Understanding the influence of textbooks on beliefs requires knowledge of the views of teachers on evolution. Some claim that as a result of the Scopes trial few teachers taught Darwinism or eugenics. For example, Branch claimed that after the Scopes trial "under the pressure of legislation, administrative decree, and public opinion, evolution quickly disappeared from textbooks and curricula across the country" (Branch, 2005, p. 5).

Unfortunately, few good studies were completed in the United States before and after the Scopes trial to determine what effect the trial actually had on evolution teaching. One of the largest studies was a 1942 survey that indicated the situation was very different than G. S. Simpson's (1997, p. 369) claim that "one hundred years without Darwin are enough," as well as Dobzanski's (1973) claim that "nothing in biology makes sense except in the light of evolution."

The survey was mailed during 1939–40 to teachers at nearly 16,000 secondary schools throughout the United States. The 59-item questionnaire was designed to evaluate biology instruction in America, and a major focus was to determine how evolution and eugenics was taught in the nation's high schools. The schools surveyed included all schools except those that had small or no biology science programs. Of the surveys sent 3,183 usable questionnaires were obtained, 2,900 from public schools, 99 from parochial, and 184 from private schools (Miller, 1942, pp. 7–8).

Eugenics

The survey authors stressed that it is critically important for both "social and political" reasons to teach "the genetic inequality of human beings" in biology classes (Riddle et al., 1942, p. 66). Riddle bemoaned the fact that teaching eugenics is "banned in communist Russia" and stressed that in a free society this important principle should be widely taught.

The study's authors lamented the fact that eugenics and nontheistic evolution are not as widely taught as fact as they should be. They found that a mere 39 schools *emphasized* evolution, and only 31 emphasized eugenics. Subjects most emphasized were health and hygiene (N= 397) and physiology (N= 263).

A total of 2,191 schools taught "the genetic inequality of human beings" (Riddle et al., 1942, p. 66), compared to only 360 schools that did not. The "genetic inequality of human beings is taught by 85.9 percent of public, 64.7 percent of parochial, and 87.1 percent of private school teachers" (Riddle et al., 1942, p. 76). Religious schools were less likely to accept eugenics, evidently discouraged by belief in the biblical teaching that all humans descended from Adam and Eve.

The authors were encouraged by the percent of schools that *do* teach eugenics but concluded that its teaching is not very effective. As a result, biology instruction in America does not succeed in teaching "our youth this scientific truth of prime importance to social and political thinking" (Riddle et al., 1942, p. 67).

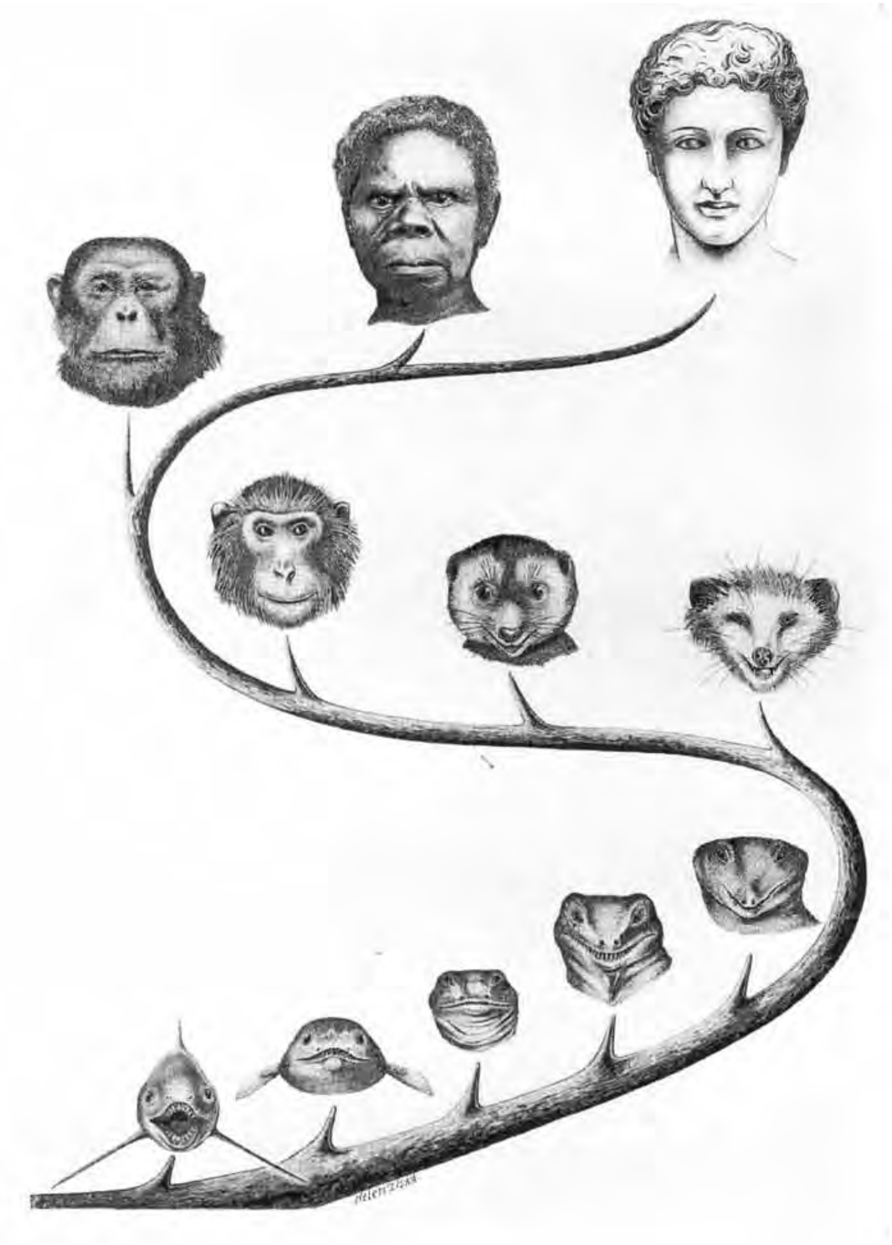


Figure 5. The Negro pictured between a chimpanzee and a white man. Adapted from Gregory (1929, Frontispiece).

Teaching Organic Evolution

The study's authors were also concerned about what they considered inadequate teaching of organic evolution. Of the public schools, 458 taught organic evolution as fact, 109 omitted teaching evolution entirely, and only 15 openly taught that evolution was false. In addition, 1,374 schools taught evolution as a "principle underlying plant, animal, and human" origins (Riddle et al., 1942, p. 70). Only 79 teachers taught evolution as applying only to subhuman organisms, 892 as a scientific *hypothesis*, and 418 as an inference only. Thus, over half of the teachers surveyed taught evolution as the source of plant, animal, and human origins (Riddle et al., 1942, p. 71).

This indicates the falsity of the common claim that evolution was often not taught after the Scopes trial, at least until evolution was reintroduced after the embarrassing Soviet space program feats. The data imply that evolution was taught as fact by the majority of schools in the 1940s. Gallup polls over the last

40 years show that around half of all Americans do not accept the evolutionary explanation of origins, indicating that most people are not convinced by evolutionary teaching.

Although the authors admitted the questionnaire was flawed and that the low return rate was a problem, the study nonetheless revealed that a significant portion of schools taught evolution as fact, especially in larger cities. They also concluded that these results were not as impressive as they appear because naturalistic evolution was, in their words, often "adulterated with theism." For example, some teachers taught human-animal evolution "plus Divine Creation," a response the author did not believe was science but theology. Only pure evolutionary naturalism was acceptable. For this reason, they concluded that the principle of evolution (defined as atheistic or nontheistic evolution where God had no role in the process) is now taught "in notably less than half of the high schools in the United States" (Riddle et al., 1942, p. 75).

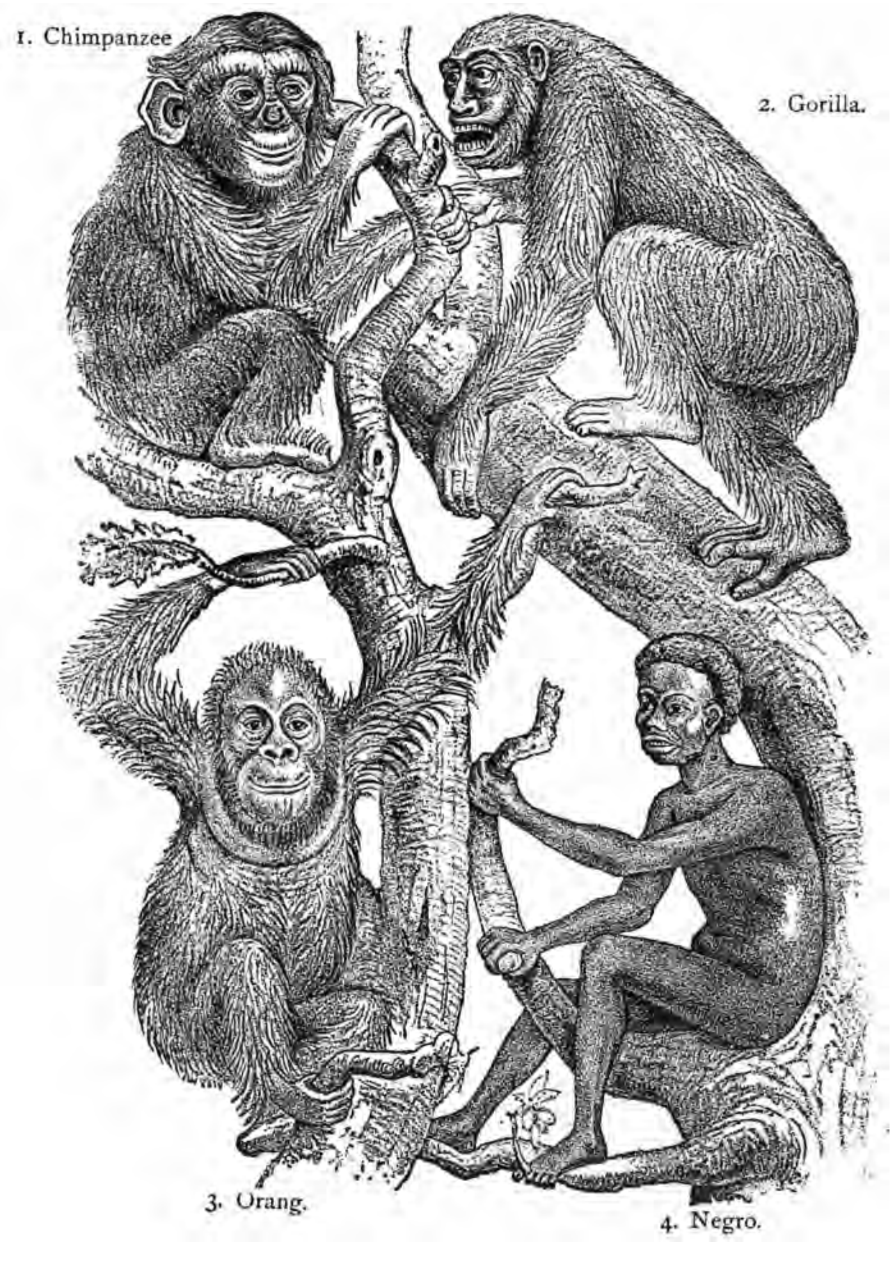

1. Chimpanzee
2. Gorilla.
3. Orang.
4. Negro.

Figure 6. A Negro pictured next to an Orang, a Chimpanzee, and Gorilla. The racist implications are obvious. Adapted from Haeckel (1879, frontispiece).

The most common reason evolution was not taught was due to community opposition. The second most common reason was due to the biology teachers' personal beliefs (208 out of 843 teachers did not teach evolution according to Riddle's definition), indicating they were creationists, and 381 did not teach evolution for other reasons.

Several respondents claimed that they did not teach evolution due to their study of science. Others saw no reason for introducing evolution, which they consider a "controversial subject" or "unimportant until more scientific 'facts' are produced." A number of teachers felt that the time could be better used to teach in other areas: "Who cares about evolution, my students don't; other topics are more important" (Riddle et al., 1942, p. 74). One teacher stated "if taught as hypothesis and not fact [there] would be little opposition anywhere," and another noted that "controversial subjects are dynamite to teachers" (Riddle et al., 1942, p. 74). Also, 11 percent felt that it was not important, and 7 percent doubted the validity of evolution (Riddle et al., 1942).

One teacher noted the reason was because a "teacher's place is not to break down what homes and churches have taught; besides it's only a theory, not a fact" (Riddle et al., 1942, p. 74). Others stated that they do not teach evolution due to "bigoted ignorance of parents" (Riddle et al., 1942, p. 74). Many of the same reasons are given today. The authors concluded that those who stated they doubted the "truth of evolution" possessed "inadequate biological training."

The authors concluded that "the principle of organic evolution [is] seriously [adversely] affected and restricted by the religious views of individuals and communities, is taught to one or another extent by about 50 percent of the teachers who replied to this questionnaire" (Riddle et al., 1942, p. 76). They argued that teaching nontheistic evolution is "essential" to effective biological instruction and encouraged teachers, administrators, and others to remedy what they considered a serious problem.

The reason they concluded it was critical to teach evolution was because the theory has significant social implications. Obviously referring to eugenics, they emphasized that "in an advanced country, in the twentieth century, there is incongruity and shame in the fact that many educational doors are locked against its intelligence, its personal, and its social implications" (Riddle et al., 1942, p. 75). More recent surveys are needed to determine what changes have occurred during the past sixty years. Very few teachers, if any, would support the teaching of eugenics today, yet the attitudes toward teaching evolutionary naturalism would probably be very similar to those in the 1940s.

Racism in Textbooks

Racism in College Biology Textbooks

Racism was also common in college textbooks. One major heredity text published both in English and German claimed that

> compared with the European races, the Negroes certainly lack foresight. In general, a Negro is not inclined to work hard in the present in order to provide for wellbeing in a distant future. The Negro is more strongly influenced than Europeans by the immediate impressions of the senses, and is therefore much more strongly attracted by gewgaws … he vacillates between a cheerful indifference and a hopeless depression. E. Fischer writes of the Negro: "He is not particularly intelligent … and above all he is devoid of the power of mental creation, is poor in imagination, so that he has not developed any original art and has no elaborate folk sagas or folk myths." (Baur et al., 1931, pp. 628–629)

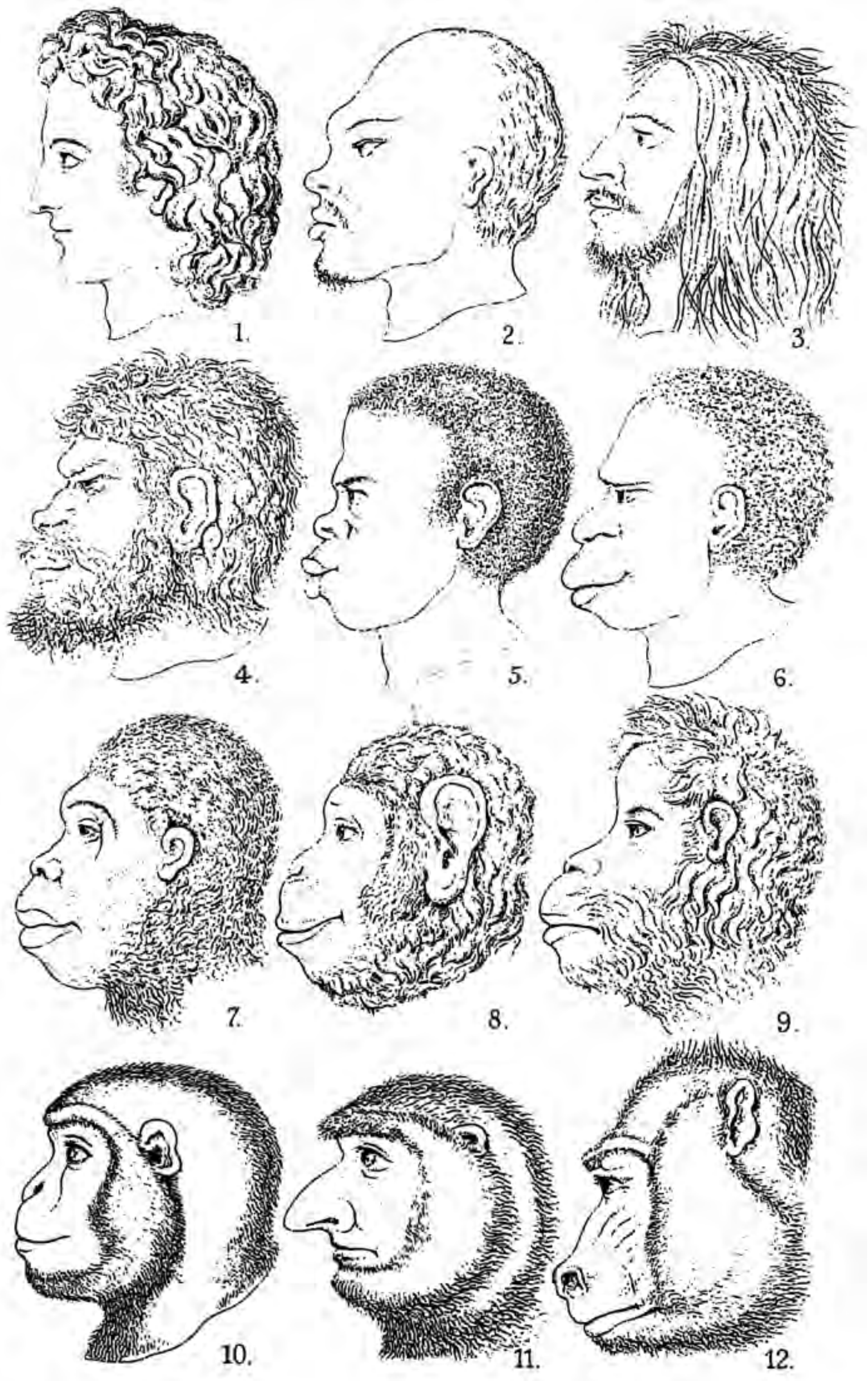


Figure 7. The illustration shows 6 human and 6 ape faces showing the gradual evolution of humans from apes. Note that the first human (number 6) is very similar to the most evolved ape (number 7). Adatped from Haeckel (1868, frontispiece).

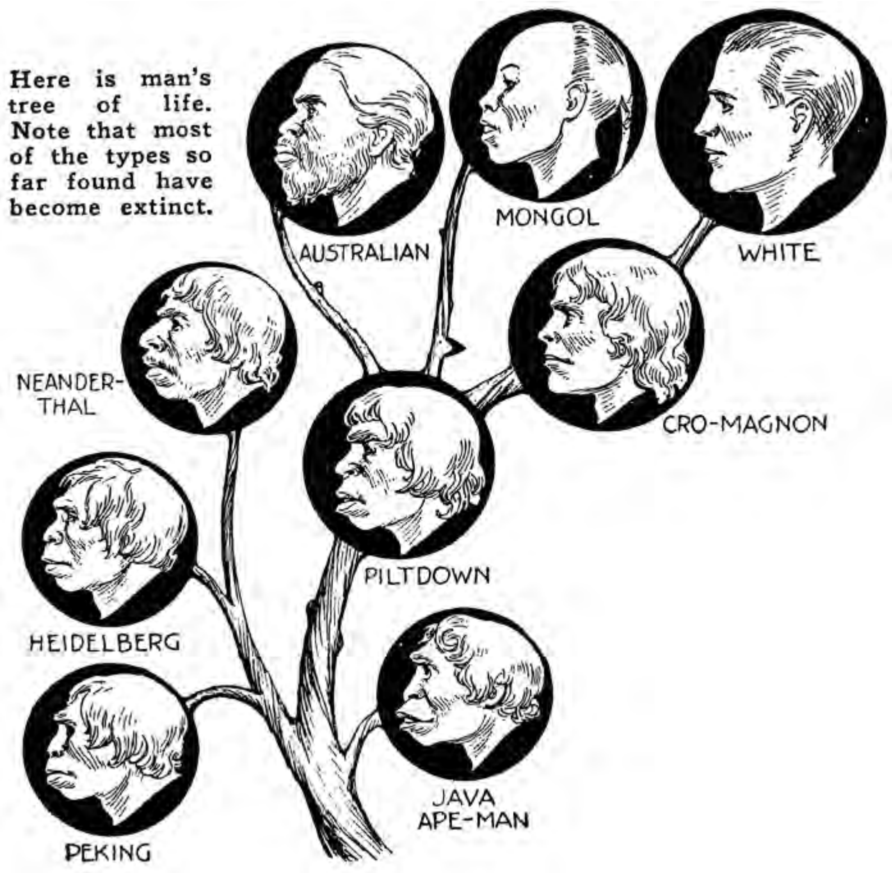

Here is man's tree of life. Note that most of the types so far found have become extinct.
AUSTRALIAN
MONGOL
WHITE
NEANDER-THAL
CRO-MAGNON
PILTDOWN
HEIDELBERG
JAVA APE-MAN
PEKING

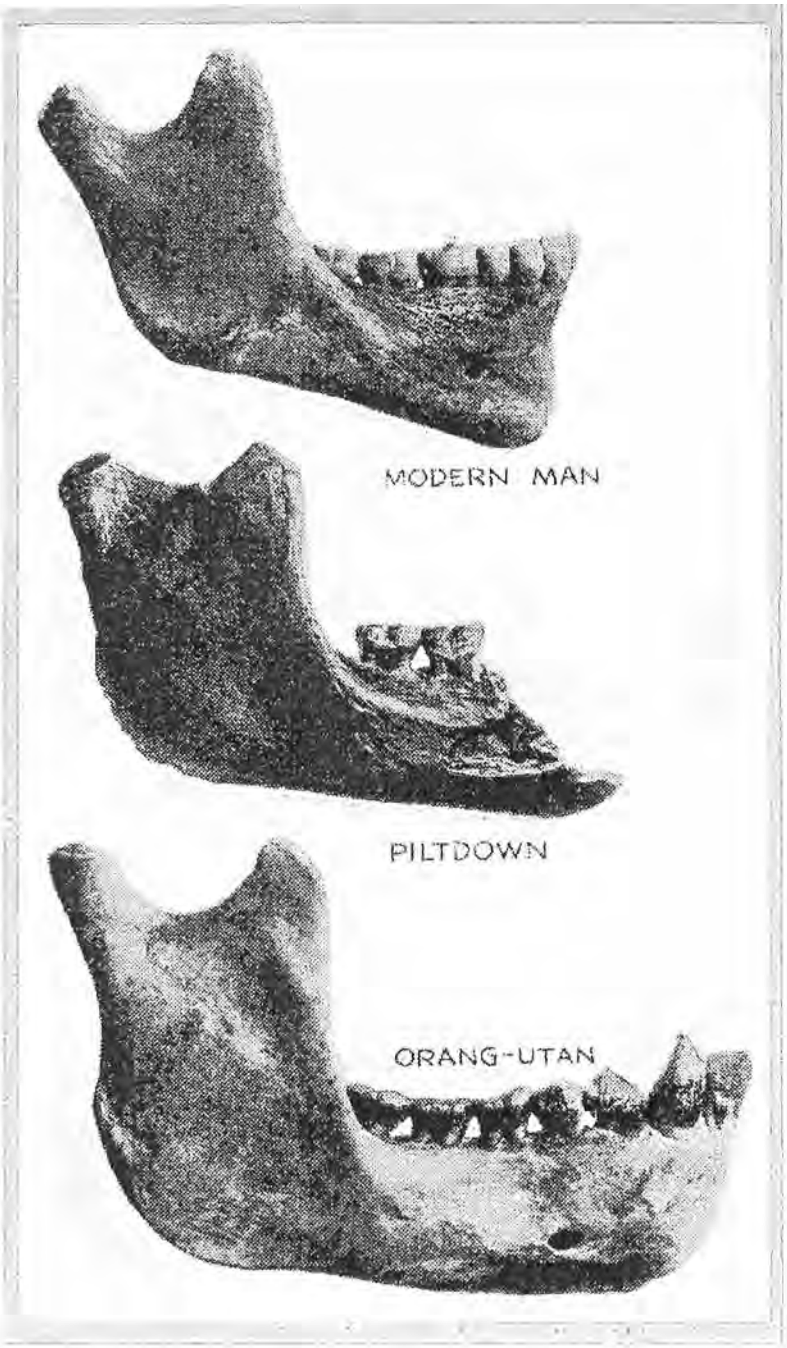
Figure 8. A human evolution "tree" showing the then common racist hierarchy. Whites are shown as being descended from Cro-Magnon and Mongols and Australians from Piltdown man, the latter now proven to be a hoax. The "negroes" are unexplainably absent from the tree. Adapted from Gregory and Mok (1931, p. 23).

As is obvious today, most all of these claims are false and without foundation. One college zoology text, which otherwise avoided discussing evolution, listed the average brain capacity of various races. For Caucasians it claimed to be 91 to 92 cubic inches; for Africans, 85, and for Australian aborigines, 75 to 79. The author then described the various apelike traits of "Negros" such as "prognathism" (a jutting ape-like jaw), and concluded that "the black and Australian races are slightly nearer the apes than civilized peoples" (Packard, 1894, pp. 309, 313). Packard (1894, p. 313) then claimed that in "civilized man the legs are one half the height of the body, but in the South Africans, Hottentots, and Bushmen the legs are a little less than half the height, and the thigh-bone is flattened from side to side, as in the gorilla." He then covers the so-called *facial angle* that measures how far "the lower part of the face protrudes, as in the Negro, the face is said to be *prognathous*; where the facial angle is high, and the face straight, as in the more intellectual [life] forms, the cranium is said to be *orthognathous*" (Packard, 1894, p. 314).

One college anthropology text included several chapters on the extensive measurements of various human traits that unambiguously resulted in a ranking putting whites on top and blacks on bottom. The data show the brain size was 1230cc for Neanderthals, 1295cc for Australians (noted as the most primitive living race), 1340cc for Negroes, 1452cc for Chinese, and 1500cc for the highest type, the Swedes (Wilder, 1926, pp. 212, 356). The author includes a phylogenetic tree of human race evolution (Wilder, 1926, p. 361).

Professor Newman, author of *Evolution, Genetics, and Eugenics*, defines evolution as "racial change," and concludes that "races are the *evolutionary units of life*" and "If there is no variation there can be no evolution" (Newman, 1932, pp. 190, 539; emphasis in original). He concludes that the human races are not equal, and racial equality is "supremely undesirable from the purely evolutionary point of view, because ... organic evolution ... depends upon the struggle between creatures possessing various variations and the consequent selection of those variations which constitute their possessors best adapted or fitted to the particular environment," i.e., the survival of the fittest (Newman, 1932, p. 539). Such claims are common in publications that focus on, or even discuss, Darwinism. He also included a chapter in his text by the infamous eugenist, Alfred Wiggam (1932).

Racism in today's biology books may be less pronounced than the examples quoted above, but the implications are clear. As late as 1957, University of Michigan professor Alfred Elliott (1957, p. 639) included a laudatory discussion of eugenics, which he defined as "the study of race improvement," in his widely respected zoology text. He claimed that if we ignore eugenics, "by the year 2000 the percentage of the population with an IQ of 115 or better will have been reduced from the current 12 percent to 7 percent, and the present 2 percent below 70 (moron, etc. group) will have doubled" (Elliott, 1957, p. 639). This prediction has failed. He also discussed the specific "dysgenic practices," which he concluded were contributing to this projected decline of human intelligence. One example



From top to bottom, jaw of a modern man, Piltdown man, and orang-utan. A study of these shows how the ape jaw is shortened and slightly lightened in the Piltdown specimen and has been reduced and given a chin in modern man.

Figure 9. The jaws from Orang-utan, also once believed to be the closest common ancestor to modern man, bridged by Piltdown man, now proven to be a hoax. Adapted from Gregory and Mok (1931, p. 22).

was modern warfare, noting that in past centuries

> the strongest, cleverest, and most intelligent men went into battle and the best of these survived to come home and become the fathers of the next generation. This was natural selection at work. Since the advent of gunpowder and subsequent deadly weapons, the strong and able are cut down equally with the less well endowed (Elliott, 1957, p. 641).

He added that modern militaries select the best men to operate the

> complicated instruments of modern warfare, but these same men are also the best stock we have and their chances of becoming the parents of the next generation are much reduced when in service as compared to life at home. For the past several hundred years, then, we have been following a policy that is definitely contrary to natural selection and undoubtedly has had its influence in reducing the quality, not the quantity, of our stock (Elliott, 1957, p. 641).

In other words, he claimed that war prunes off the best, resulting in devolution (backwards evolution). In his text humans are called "stock," as in livestock, and the "quality" of the stock is defined in animal terms.

Racism in School Reference Books

Typical of the views of the leading American educators at this time is an 1898 *Encyclopaedia Britannica* article that, under the heading "Negro," stated "the nearly unanimous consent of anthropologists" is that Negroes occupy "the lowest position in the evolutionary scale." As evidence for this conclusion, the author argued that the brain's cranial sutures "close much earlier in the Negro than in other races." This "premature ossification" prevented "further development of the brain." Furthermore "many pathologists have attributed the inherent mental inferiority of the blacks, an inferiority which is even more marked than their physical differences" to this putative "premature ossification." The article concluded:

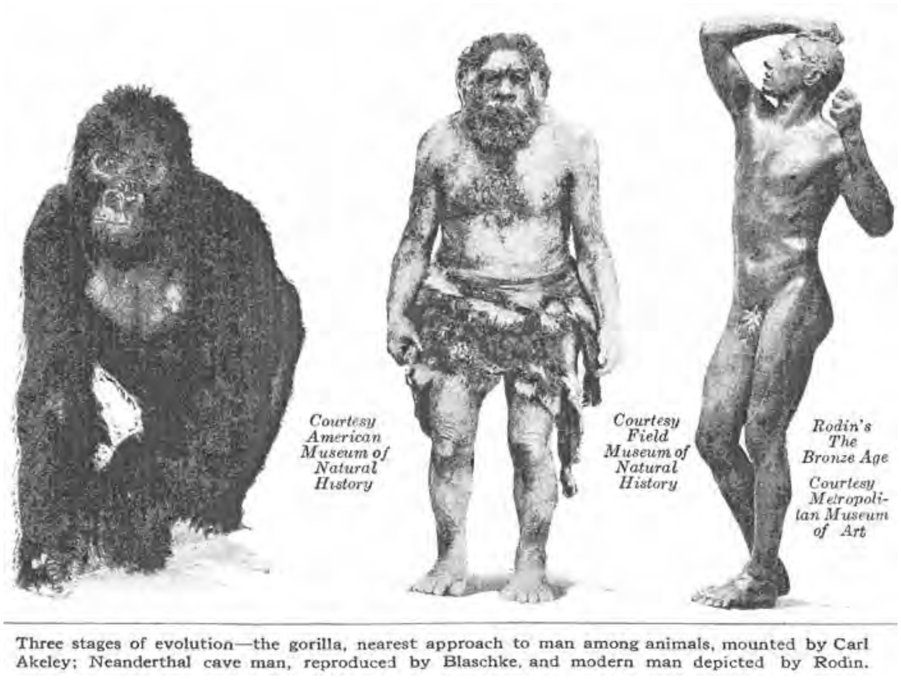
> No full blooded Negro has ever been distinguished as a man of science, a poet, or an artist and the fundamental equality claimed for him by ignorant philanthropists is belied by the whole history of the race. (*Encyclopaedia Britannica*, 1898, p. 318)

Up until at least the 1903 edition, the *Encyclopaedia Britannica* also claimed that the world has never produced any "great" Negroes.

Racism in Textbook Illustrations

Textbook drawings depicting our supposed immediate ancestors, such as *Homo erectus* and *Homo habilis*, typically have *very pronounced Negroid* race characteristics—dark skin, kinky hair, and Negroid facial features. Modern man (*Homo sapiens*), though, is often pictured as having light skin, straight hair, a flat forehead, a narrow nose, and small lips (Howell, 1965, pp. 157–158). Most of the drawings of "ape-men" and early or prehistoric humans show very pronounced Negroid traits (e.g., Constable, 1973, pp. 21, 29–31; White and Brown, 1973, pp. 8, 66; and the cover of the April, 1984 issue of *Science 84*).

The fact that certain Negroid facial features are closer to the facial characteristics of some primates (the flat nose, large lips, and sloping forehead, as well as the cheek and jawbone construction) than to white humans has lent superficial support to this contention. The fact that other Negroid features are less similar to primates than certain traits common among whites is often ignored. For example, most primates have white skin, straight hair, and large amounts of body hair as do many Caucasian groups—whereas many blacks usually have dark skin, kinky hair, and a small amount of body hair.


Courtesy American Museum of Natural History
Courtesy Field Museum of Natural History
Rodin's The Bronze Age
Courtesy Metropolitan Museum of Art

Three stages of evolution—the gorilla, nearest approach to man among animals, mounted by Carl Akeley; Neanderthal cave man, reproduced by Blaschke, and modern man depicted by Rodin.

Figure 10. Picture of a gorilla, then widely believed to be our closest living common evolutionary ancestor, to Neandertal, now recognized to be another race of modern man, to modern man, as shown by French sculpture Rodin. Modern man is obviously a Caucasian. Adatped from Armstrong (1929, p. 19).

Nazi-Sanctioned Textbooks

Darwinism Permeates Nazi Biology Textbooks

Numerous similarities related to teaching Darwinism also existed in Nazi Germany biology textbooks. After the Nazis took over Germany, biology instruction and textbooks rapidly became saturated with Darwinian evolution (Bendiscioli, 1939; Wolf, 1944). In 1938 the Ministry of Education published an official school curriculum handbook that included a chapter on biology requirements (Linder and Lotze, 1938). The biology goals were developed by the Nazi Teachers' League, which emphasized evolution, including the evolution of the human races.

The biology curriculum included teaching plant and animal evolution in grades three and four, and human evolution in grade five. The topics required for biology instruction in the upper grades included human evolution and the origin of human races (Linder and Lotze, 1937, pp. 239–246).

The guidelines repeatedly stressed that evolution was central to both the Nazi worldview and the biology curriculum. The curriculum specifically mandated a detailed coverage of evolution, including the evolution of human races by "selection and elimination" of the less fit races. It stipulated that students must accept as "self-evident this most essential and most important natural law of elimination [of the unfit] together with evolution" (Linder and Lotze, 1938, pp. 148–149). Eugenics, although introduced in geography and history, was

> developed much further in biology. The teaching of racial studies and eugenics soon was required in designated classes. This order was

> a bonanza for the extremists whose eugenics texts had gone unread for years. Hundreds of books and pamphlets were published for all levels of instruction. Written in turgid and propagandistic prose … the books, after providing minimal introductions to genetics and prehistory, were dedicated almost entirely to a totally [we recognize now] unscientific definition of races and their supposed characteristics (Nicholas, 2005, pp. 84–85).

Teachers in the fifth grade were required to cover the emergence of primitive human races "in connection with the evolution of animals" (Linder and Lotze, 1938, p. 141). Eighth-grade students were taught evolution in far more detail, including the worldview of Darwin, and its political implications, as well as the origin and evolution of the human races. The material stressed that while the individual "is temporary, the life of the species to which it belongs is lasting," and is ruled by the laws of evolution (Linder and Lotze, 1938, pp. 157).

Textbooks Mix Darwinism, Nazism, Racism

The close connection between Nazism and Darwinism was explained in detail in many of the Nazi biology textbooks (Kramp and Benl, 1936). One text, written for fifth-grade girls, after explaining that all life is "in a continual battle for survival," added that the animal that does

> not secure sufficient territory and guard it against other predators, or lacks the necessary strength and speed or caution and cleverness will fall prey to its enemies…. The battle for existence is hard and unforgiving, but is the only way to maintain life. This struggle eliminates everything that is unfit for life, and selects everything that is able to survive…. The laws of nature are built on a struggle for survival (Wiehle and Harm, 1942a, p. 168).

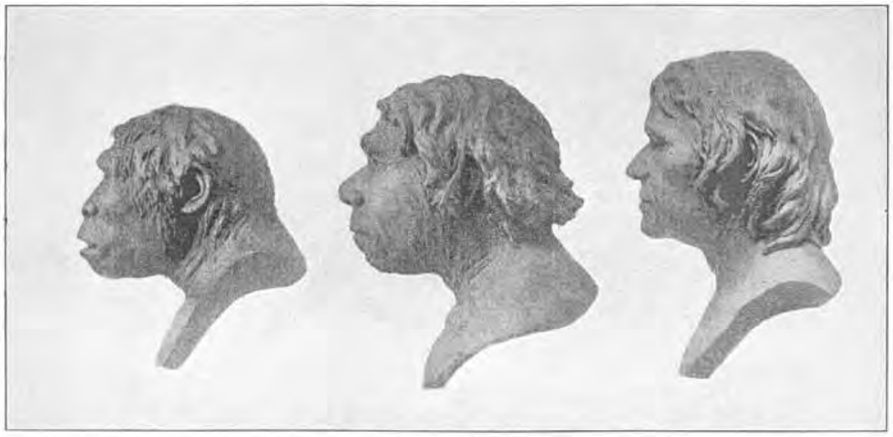


FIG. 258. Three stages in human development

Restorations to suggest the probable appearance of primitive types of human beings. From left to right, *Pithecanthropus erectus* (Java), *Homo neanderthalensis* (Germany), and the "Man of Cro-Magnon," *Homo sapiens* (France). These photographs are of figures molded by Professor J. H. McGregor on the basis of fragments of primitive man discovered from time to time in various parts of the world

Figure 11. The evolution of man showing Java man, Neanderthal man, and modern man. Adapted from Gruenberg (1924, p. 495)

The implications of these ideas to Nazi war policy are obvious. The text then gave a set of examples to support the above claim, concluding that

> every creature has to fight for its survival … summarized in the principle: Each individual wants to maintain its existence in the struggle for survival (self preservation instinct, fighting will, individuality) (Wiehle and Harm, 1942a, p. 168).

The text then added, "Mankind, too, is subject to these natural laws, and has won its dominant position through struggle" (Wiehle and Harm, 1942a, p. 169). Furthermore, each person must fight for his place in his community, and those who do not survive in the Darwinian

> struggle for survival … will perish. Our Führer tells us: "He who wants to live must fight, and he who does not want to fight in this world of perpetual struggle does not deserve to live!" (Wiehle and Harm, 1942a, p. 169, quoting *Mein Kampf*)

In part II the authors continue, noting that all living things that are successful

> in the struggle for survival are not satisfied merely with existence, but seek to preserve their species as well. Here too is a drive that corresponds to natural law. Without this drive, species would long since have vanished…. Maintaining the species also is a struggle. The deer ruts in the fall and offers battle to other deer in competition for females. The stronger and cleverer deer passes on his inheritance. The rooster defends his status and his hens courageously. The battle for females selects the fittest (Wiehle and Harm, 1942a, pp. 169–170).

Furthermore, the "drive for maintaining the species is stronger than the instinct for self-preservation" (Wiehle and Harm, 1942a, p. 171). The text then details the importance of sacrificing one's life for the Nazi state and evolution. Examples provided to support the Nazi goal of sacrificing one's life for the Nazi state include the fact that a female rabbit defends her

> young against hawks, often at the cost of her own life. A fox risks its life to secure food for its young.

> The life of the individual can be sacrificed to assure the continuation of the species (The law of the species is stronger than that of the individual!) (Wiehle and Harm, 1942a, pp. 171–172).

This text then claims that among all living creatures a natural law exists: the production of numerous offspring. Nowhere on earth exists a life-form that produces only one or two offspring because that "would inevitably lead to extinction." Therefore a

> large number of offspring are an important means in the struggle for survival of the species. The house mouse can resist the field mouse simply through its larger number of young. In such instances, one can speak of a battle of births (Wiehle and Harm, 1942a, p. 172).

This argument was used by the Nazis to instigate their policy of encouraging German women by propaganda and awards, such as money and honors, to have large families. The Nazis also justified their wars for territory by Darwinism.

> Each species strives to conquer new territory. The species goes before the individual. History provides us with enough examples to prove that mankind, too, is under this law. In the midst of their prosperity, the Romans lost the desire to have children. They sinned against the law of maintaining the species. Their state was undermined and overcome by foreign peoples…. Our nation, too, once hung in the balance. National Socialism restored to the German people the will to have children, and preserved our people from certain decline, which would have been inevitable under the law of species and the law of the greater number of offspring.
>
> Here, too, we can recall the Führer's words: "Marriage, too, cannot be an end in itself, but rather it must have the larger goal of increasing and maintaining the species and the race. That only is its meaning and its task." … The goal of female education must be to prepare them for motherhood (Wiehle and Harm, 1942a, p. 172, quoting *Mein Kampf*).

In part III the text again stresses that humans "do not live as individuals like animals" do, but as a society that has "come together as ethnic states," adding that

> the individual has only one purpose: to serve the whole group. Major accomplishments are possible only by the division of labor. Each bee risks its life without hesitation for the whole. Individuals who are not useful or are harmful to the whole are eliminated. The species is maintained by producing a large number of offspring. It is not difficult for us to see the application of these principles to mankind: … The ethnic state must demand of each individual citizen that he does everything for the good of the whole, each in his place and with his abilities…. "He who loves his people proves it only by the sacrifices he is prepared to make for it."
>
> If a person acts against the general interest, he is an enemy of the people and will be punished by law. A look at our history proves that we as a people must defend our territory to preserve our existence. "The world does not exist for cowardly nations" … Military service is the highest form of education for the Fatherland. "The task of the army in the ethnic state is … to serve as the highest school for education in service of the Fatherland" (Wiehle and Harm, 1942a, p. 173, quoting *Mein Kampf*).

The text concluded by stating that every "citizen of the nation must be ready to do all for the good of the whole, for the will of the Führer, even at the cost of sacrificing his own life…. The good of the nation goes before the good of the individual" (Wiehle and Harm, 1942a, p. 174). Furthermore, these

> natural laws are incontrovertible; living creatures demonstrate them by their very survival. They are unforgiving. Those who resist them will be wiped out. Biology not only tells us about animals and plants, but also shows us the laws we must follow in our lives, and steels our wills to live and fight according to these laws. The meaning of all life is struggle. Woe to him who sins against this law: "The person who attempts to fight the iron logic of nature thereby fights the principles he must thank for his life as a human being. To fight against nature is to bring about one's own destruction" (Wiehle and Harm, 1942a, p. 174, quoting *Mein Kampf*).

Government Darwinian Indoctrination

One of the leading authorities on biology pedagogy during the Third Reich was Paul Brohmer, a professor at Kiel Teachers College (Brohmer, 1933). His book *Der unterricht in der Lebenskunde (Instruction in the Life Sciences)* was part of a series devoted to "National Socialist Pedagogy in School Instruction" (Brohmer, 1943). Brohmer wrote that Nazi ideology was based on the laws of biology. After glorifying Darwin for inaugurating a "new, more fruitful era of biology," he criticized Darwin for the individualism inherent in some of his writings because it reflected English liberalism. He believed that evolution should stress holism and collectivism rather than individualism. Brohmer stressed, however, that this criticism was not directed against evolution, which he fully accepted, just against certain parts of Darwin's writings.

Another instructor of biology teachers, Ferdinand Rossner, in a book approved by the Nazi Ministry of Education, also pressed for extensive coverage of evolution and eugenics in all biology classes (Rossner, 1937, p. 100).

After the Nazis had sufficient time to revise the curriculum to correspond to their ideological agenda, all higher-level German biology texts in the late 1930s and early 1940s included extensive discussion of evolution, including evolution of the human races and the biological ranking that evolution produced. The fourth volume of the 1942 edition of the officially endorsed textbook, *Biologie Für Oberschule und Gymnasium*, contained an entire chapter on evolution and its importance for the Nazi worldview (Graf, 1942, pp. 320–348).

Dr. Graf went beyond Darwinian evolution, stressing that evolution has proven humans were not specially created but rather are just another animal and that evolution, furthermore, substantiates the Nazi teaching of human inequality. In chapter 10, titled "Racial Science" (Graf, 1942, pp. 349–394), fifteen pages are devoted to human evolution and the common ancestors of humans and apes. He included illustrations of our racial lineage as documented by the evolution of the human skull (Graf, 1942, pp. 354–355). The text included much discussion of the Jewish "race" in contrast to the superior Aryan "race" (Graf, 1942, pp. 372–382).

In another biology text published in 1934, Europeans were

> divided into five main racial types: Nordic, Dinaric, Alpine, Mediterranean, and Eastern/Baltic. Photographs and charts illustrated and compared physical characteristics. Needless to say, the best-looking and best-groomed were the Nordics. Eyes were compared, as were lips, chins, noses (Nordic—thin; Mediterranean—curved; Dinaric—quite fleshy; Eastern—thick, not curved; and so on), faces, heads, and body shapes. To this were added spiritual and intellectual qualities that … naturally, demonstrated the superiority of the Nordic race (Nicholas, 2005, p. 85).

A leading biology text for *Mittelschule* with the official imprimatur of the Reich Ministry of Education gave extended attention to human evolution (Wiehle and Harm, 1942b). Of the ten main chapters, two were on evolution and one was devoted exclusively to human evolution. The human evolution chapter alone comprised over 14% of the main part of the text.

One text that covered evolution and the origin of humans in detail recommended that students visit a zoo to view primates so as to reinforce what the text claimed was the close similarity between humans and apes (Wiehle and Harm, 1942b, p. 132). As this text made clear, all Third Reich German school children were to be taught that some lower primate was their evolutionary relative.

The Nazi Ministry of Education also published lists of books recommended for school libraries, and many of them taught Darwinism. One approved book by University of Berlin zoologist Richard Hesse, titled *Abstammungslehre und Darwinismus (Evolutionary Theory and Darwinism)*, was devoted to proving evolution. The 1936 edition contained a chapter titled "Evolutionary Theory is Valid Even for Humans" (Hesse, 1936b, pp. 48–55).

Later the same year, the Ministry of Education approved *Rassenpflege und Schule (Racial Care and School)*, wherein medical professor Martin Staemmler taught neo-Darwinian evolution of human races by mutation and natural selection. He also expounded on the racial struggle for survival and the important role of *Lebensraum* (the need for more living space to allow the Aryan race to expand) in that struggle (Staemmler, 1937, pp. 13, 32–36).

A separate section of many texts discussed Jews as an inferior race, "not a 'pure' race," but rather a "complicated mixture of Oriental and Middle Eastern peoples" that "could easily be distinguished from the latter by their even fleshier noses" (Nicholas, 2005, p. 85).

The Meyer Text

A leading biology book published in Nazi Germany at about the same time that Hunter's book was in print, *Lebenskunde-Lehrbuch der Biologie für Höhere Schulen* (Life-Sciences-Biology textbook for high schools) (Meyer et al., 1940; Meyer et al., 1942), came to the same conclusion as the texts by Hunter, Coulter, and Sanders. Instead of "Negroes" it focused on "Jews" and "Gypsies" as examples of "inferior races." This text concluded that "primitive races" that live in remote areas were "physically, as well as mentally, far behind the highly developed races ... The most highly developed races are the master races; greater aptitude enabled them to found superior cultures and civilizations" (quoted in Liebster, 2000, pp. 388–390).

The authors then claim that although all humans "are subject to the iron law of natural selection" and, in the past, natural selection had

> exterminated men ill with severe inherited weaknesses; however, in modern culture these are retained and not prevented from proliferating.... Modern culture has worked against nature. It has chiefly perpetuated the survival and propagation of the weakly and sick to the detriment of the … [race] (quoted in Liebster, 2000, pp. 288–390; italics in original).

Darwin made the same claim in his 1871 book.

The textbook also claimed that the Jews are "a racial mixture of parasitic nature" and that the "disharmony of the Jewish racial mixture" is proved by the frequency of certain diseases among Jewish-Gentile offspring. The authors then argue that the "most repugnant features of the Jewish people" are rooted in their mental

> craftiness, physical and mental uncleanness, cruelty, greed, a distaste for physical labor, particularly the vocation of farmer or soldier. ... It is therefore right to view Jews as a parasitic nation or a racial mix of parasitic characteristics that causes its host nation only disadvantage and

> spells disaster (quoted in Liebster, 2000, pp. 388–390).

Furthermore, the text author stressed that

> it is our sacred and civil duty to protect our blood from being contaminated with alien blood, especially Jewish blood. No greater shame can be inflicted on the honor of the German nation than the breaking of this law (quoted in Liebster, 2000, pp. 388–390).

In addition, the "Gypsy nation is also a foreign body and consequently has to be rejected" (quoted in Liebster, 2000, pp. 388–390). The authors then agree that "racial reinvigoration of German blood" requires drastic action and that Nazi Germany recognizes the

> mortal danger facing civilized nations due to a violation of fundamental laws of life, [and] has therefore as a consequence adjusted its policies toward armed combat of these dangers.... After the assumption of power by the National Socialism, our first concern was to protect the German nation from further increase of hereditarily ill individuals.... The passing in 1933 of the *Law for the Prevention of Hereditarily Diseased Offspring* stems from this desire (quoted in Liebster, 2000, pp. 388–390, italics in original).

The text concludes with the amazing statement that this new German "law is an immense blessing because it "removes the calamitous results in the absence of natural selection within modern culture and serves us with the aid of advanced science to keep our race clean in a humane way" (quoted in Liebster, 2000, pp. 388–390).

Many, if not most, German biology textbooks of the Nazi period came to similar conclusions. This is a major reason for the high level of the German people's support for Nazism. Another reason for teaching Darwinism was that Hitler's goal of "total militarization" required "acceptance of war as an integral part of a life of Darwinian struggle" (Blackburn, 1985, p. 117).

Conclusions

The texts reviewed above illustrate the typical racist ideas widely found in textbooks for close to a century after Darwin introduced his 1871 watershed work on human evolution. Many worse examples exist, as do a few that presented less objectionable discussion of race. It was a small leap from the ideas commonly found in these textbooks to the overt racism as practiced by the Ku Klux Klan, the Aryan Nation, and other hate groups during the period that these texts were widely used in public and in many private schools throughout the Western world. Many of these texts are still quoted by the Ku Klux Klan and in the literature from similar racist groups.

These texts have influenced millions of students, some of whom would become government officials, professors, judges and ministers. As a result, even some religious books, no doubt influenced by these widely used texts, contained racist overtones. In a book written for popular consumption to defend his views, Moser (1974, p. 51) used Scripture to support his conclusion that "it is only that Negro that has a mixture of white genes in his system that has risen to the level where he has produced on the level with the white race." In a modern example, Ku Klux Klan leader David Duke used Darwinism to support his racist views, quoting well-known scientists to attempt to "harmonize" his religious views with science (Bergman, 2005).

This fact stresses the relevance of these old references in understanding our contemporary social problems. It will never be fully known how greatly these books influenced racist policies and attitudes during the turbulent period in America when racism was expressed in everything from blocked job opportunities to lynchings. Fortunately, less racism exists than otherwise might because, after the Scopes trial, some textbooks reduced or eliminated all coverage of Darwinism (Witham, 2002). It is clear, though, that Darwinists made a major contribution to racism in America and Germany and other Western nations, just as later books refuting those racist ideas have had a major influence in the opposite direction.

The Nazis aggressively pushed the teaching of Darwinism in the schools during the entire time that they ruled Germany, just as is now being done in America and other nations (Klicka and Harris, 1992). In Germany, Darwinism indoctrination was part of the process to ready the population for the elimination of the Jews and other putative inferior races to achieve the goal of producing a superior race.

Racism, especially anti-Semitism, was a major Nazi policy, and Darwinism was part of the strategy the Nazis used to achieve this social goal (Wegner, 2002). Clearly, "Darwinism provided support for Nazi propaganda campaigns warning of the threat of Jewish blood to [the] German population" (Wegner, 2002, p. 71). They failed, and we today view their attempt as one of the worst acts of inhumanity in history; yet the West is pursuing a Darwinian indoctrination policy today that is very similar to that of Nazi Germany.

Acknowledgments

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Origin of Appalachian Geomorphology

Part III: Channelized Erosion Late in the Flood

Michael J. Oard*

Abstract

Water and wind gaps are transverse erosional cuts through higher elevations. These features are abundant in the Appalachian Mountains, and several of them are briefly described. What they all have in common is the inability of actualists to offer a viable hypothesis for their formation. The common antecedent and superimposed stream hypotheses do not explain the observations. However, both water and wind gaps can be explained by the channelized flow phase during the runoff of the Floodwater from the Appalachians.

Introduction

Several independent lines of evidence suggest the erosion of up to 6.5 km of rock off of the Appalachian Mountains, depositing thick sediments on the eastern continental margin of the United States (see part I of this article, Oard, 2011b). The nature of the continental shelf-slope system indicates rapid, continuous sedimentation, suggesting a large erosional event, rather than extended, slow processes. During this event, as the Appalachians were eroded, large erosion surfaces were formed on both sides of the mountain range (see part II, Oard, 2011c). Other indications of the rapidity of the event are the erosional remnants (inselbergs or monadnocks) and surficial gravel lag deposits on the plateaus west of the Appalachians, similar to those found in the western United States (Klevberg and Oard, 1998; Oard 2008a, 2008b; Oard and Klevberg, 1998, 2005; Oard et al., 2005, 2006a, 2006b, 2007).

As far back as William Morris Davis in the early twentieth century, geologists have attempted to explain these erosion surfaces by various erosional cycles, but each hypothesis has been refuted by observation or evidence. The currently popular "weathering hypothesis" seems so only by default and has many problems of its own. Essentially, the actualistic scientists do not have a viable hypothesis that explains erosion surfaces—especially planation surfaces. However, the diluvial explanation of Flood runoff during the retreating stage of the Flood provides a straightforward mechanism (Oard, 2008a) that accords well with observations.

Late Flood Appalachian uplift, combined with decreasing Flood levels, caused sheet flow currents of the early retreating stage to flow off the Appalachians to the east and the west, rapidly eroding and planing the land on either side of the Appalachian Mountains. Erosional remnants were left behind on the Piedmont and in the Great Valley. Resistant rocks were carried long distances by large, energetic currents to the east, south, and west. As the Flood level continued to drop, the sheet flow currents were broken into channelized flows of steadily diminishing size and velocity, producing another unique set of landforms superimposed upon those already formed.

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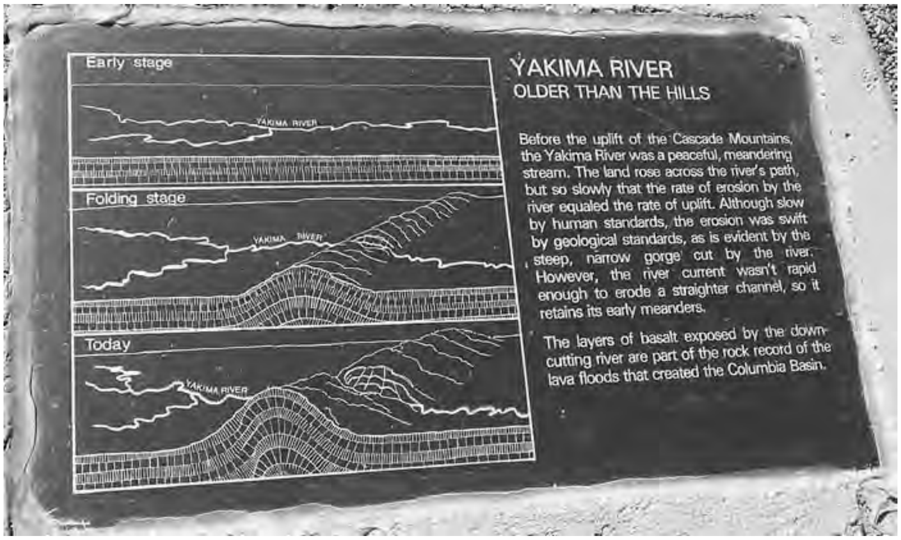

YAKIMA RIVER
OLDER THAN THE HILLS

Before the uplift of the Cascade Mountains, the Yakima River was a peaceful, meandering stream. The land rose across the river's path, but so slowly that the rate of erosion by the river equaled the rate of uplift. Although slow by human standards, the erosion was swift by geological standards, as is evident by the steep, narrow gorge cut by the river. However, the river current wasn't rapid enough to erode a straighter channel, so it retains its early meanders.

The layers of basalt exposed by the down-cutting river are part of the rock record of the lava floods that created the Columbia Basin.

Figure 1. The antecedent stream hypothesis shown on a plaque near a Yakima River water gap, Washington. First, a stream is established; then, as a ridge slowly uplifts, the stream erodes through the barrier.

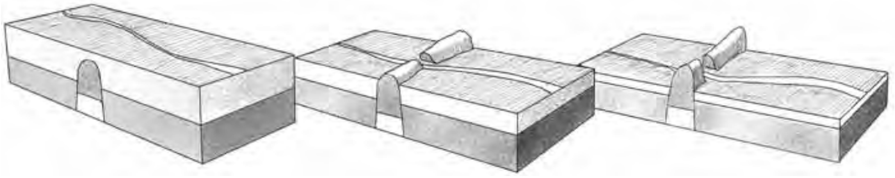

Figure 2. Block diagram of the superimposed stream hypothesis. The stream maintains its same course as most of the covermass (top layer) is eroded. Drawing by Bryan Miller.

Linear Erosion Features

Superimposed on widespread sheet erosion features of the Appalachians and the offshore continental margin are linear erosion features. These include: (1) water and wind gaps through the Valley and Ridge and Blue Ridge Provinces, (2) valley erosion in the Valley and Ridge Province, (3) vertical dissection of the plateaus west of the Valley and Ridge Province, and (4) submarine canyons in the continental shelf-slope system. The offshore submarine canyons are beyond the scope of this paper but are discussed elsewhere (see Oard, 2008a).

Definitions

A water gap is "a deep pass in a mountain ridge, through which a stream flows; esp. a narrow gorge or ravine cut through resistant rocks by an antecedent stream or superposed stream" (Neuendorf et al., 2005, p. 715). Although a water gap is defined as cutting through a "mountain ridge," in practice this definition applies to any perpendicular cut through any topographical barrier, including a plateau (Douglas, 2005). In other words, a water gap can be considered a perpendicular cut through a mountain range, ridge, or other structural barrier. An antecedent stream is a stream that maintains its early course or direction despite subsequent uplift of the surrounding region (Neuendorf et al., 2005). Figure 1 shows a block diagram of an antecedent stream forming a water gap. The superimposition theory states that a stream established on a new surface maintains its course during downward erosion despite different rock types and structures encountered (Neuendorf et al., 2005). Figure 2 is a block diagram showing the formation of a water gap by superimposition.

The dictionary definition of a water gap is another case where assumptions override observations: it presupposes that water gaps are created by either antecedence or superimposition. Definitions of geological features should be purely descriptive without undue speculation concerning origin. Ironically, uniformitarian scientists claim five possible mechanisms for the formation of water gaps, and the inclusion of only two in the dictionary suggests further bias in the definition. The other three mechanisms for transverse drainage are: (1) perpendicular faults, (2) relief inversion followed by a reversal in drainage, and (3) stream piracy (Figure 3). The irony of the definition in Neuendorf et al. (2005) is that most geologists have rejected antecedence and superposition for most water gaps across the earth.

The stream piracy model seems to be the current favorite among geomorphologists. However, stream piracy also has trouble explaining water gaps. Bishop (1995, p. 449) stated:

> The key process in stream capture, namely, drainage head retreat, is difficult to envisage as a normal part of drainage net evolution, especially in the light of recent findings on drainage hollow evolution. Stream capture may therefore be a relatively rare event in drainage net evolution. This, and uncertainties with interpretations of supposed elbows

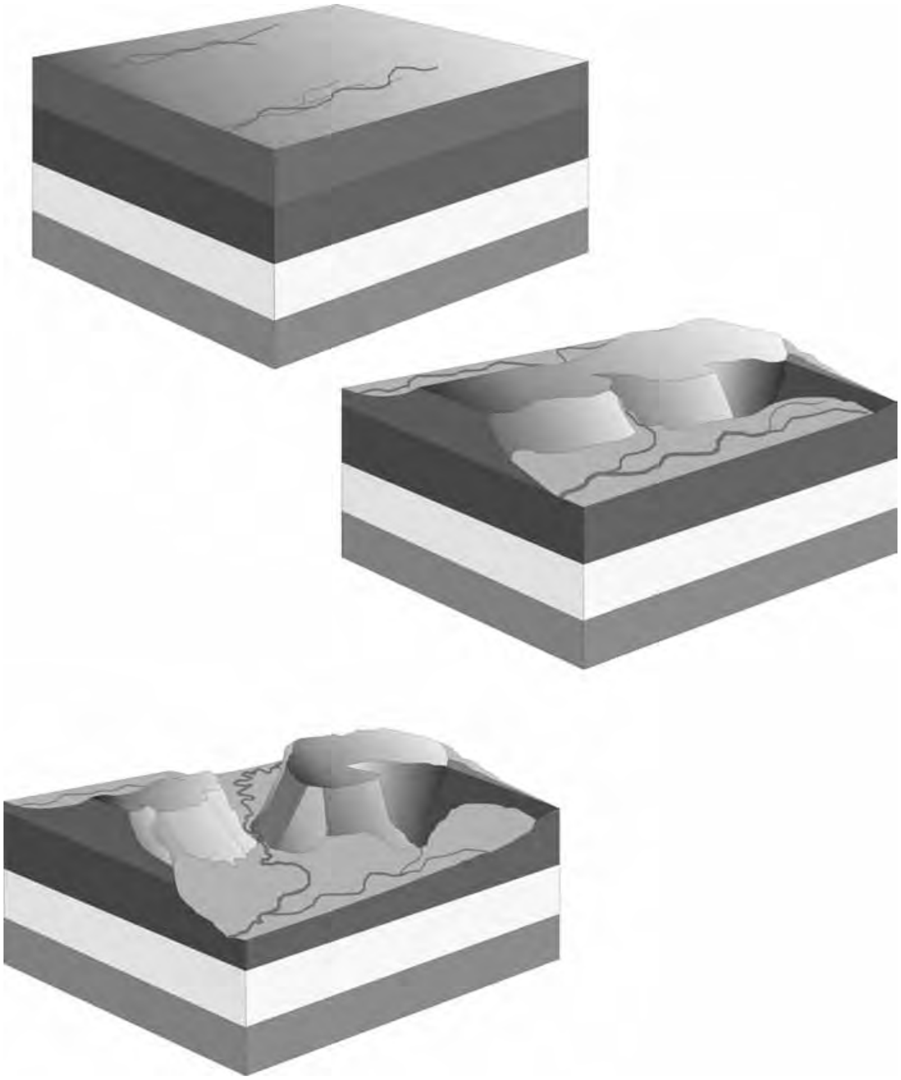

Figure 3. Schematic of stream piracy drawn by Peter Klevberg. As the stream valleys erode, a tributary stream supposedly erodes through the intervening ridge and eventually captures part of the stream on the other side of the divide.

> of capture, mean that stream capture should not be routinely invoked in interpretations of long-term drainage evolution. Further uncertainties associated with the maintenance of drainage lines during the erosion of significant crustal sections, especially in faulted and folded terrains, diminish the likelihood of many supposed examples of stream capture. It is more likely that examples of drainage rearrangement attributed to stream capture were generated by drainage diversion, but even this may involve special conditions.

In a flume experiment, Douglas and Schmeeckle (2007, p. 38) discovered that the mechanism of stream piracy is very difficult and needs extra "help":

> The final piracy experiment successfully produced a transverse drainage through headward erosion, but required the retreat of a strongly asymmetrical scarp ridge and required much more time than the other experiments. This supports Bishop's (1995) argument concerning piracies over utilization.

Stream piracy is not considered too probable for the Appalachian drainage.

A wind gap is "a shallow notch in the crest or upper part of a mountain ridge, usually at a higher level than a water gap" (Neuendorf et al., 2005, p. 723). The notch in a ridge has to be an *erosional* notch, not a notch caused by faulting or some other mechanism. In other words, the entire ridge was once near the same altitude, until a notch was eroded across its top. A wind gap is considered an ancient or incipient water gap, thought to have formed either when the sediments were thicker in the surrounding valleys or before the ridge had uplifted, if the ridge is a fault block. Thus, wind gaps are thought to have been originally cut by rivers before being uplifted above the present drainage or before the river changed its course. So the difference between water and wind gaps is that the former have present drainage, while the latter do not. Only wind passes through the gap at present, which is why it is called a *wind* gap.

Water and Wind Gaps

Water gaps are numerous in the Appalachian Mountains (Ver Steeg, 1930; Thompson, 1939; Strahler, 1945; Ahnert, 1998). Hundreds of them have been cut through resistant ridges, as have many wind gaps (Thornbury, 1965). Alvarez (1999, pp. 267–268) stated: "The Appalachian Valley and Ridge Province is the classic area for the problem of rivers cutting through the narrow ridges of fold-thrust belts." Speculation and controversy over the origin of water gaps have been going on for about 150 years. Although the major rivers flow through water gaps of the Valley and Ridge and Blue Ridge Provinces, many tributary streams also flow through water gaps, especially in the northern Appalachians (see Figures 23 and 24).

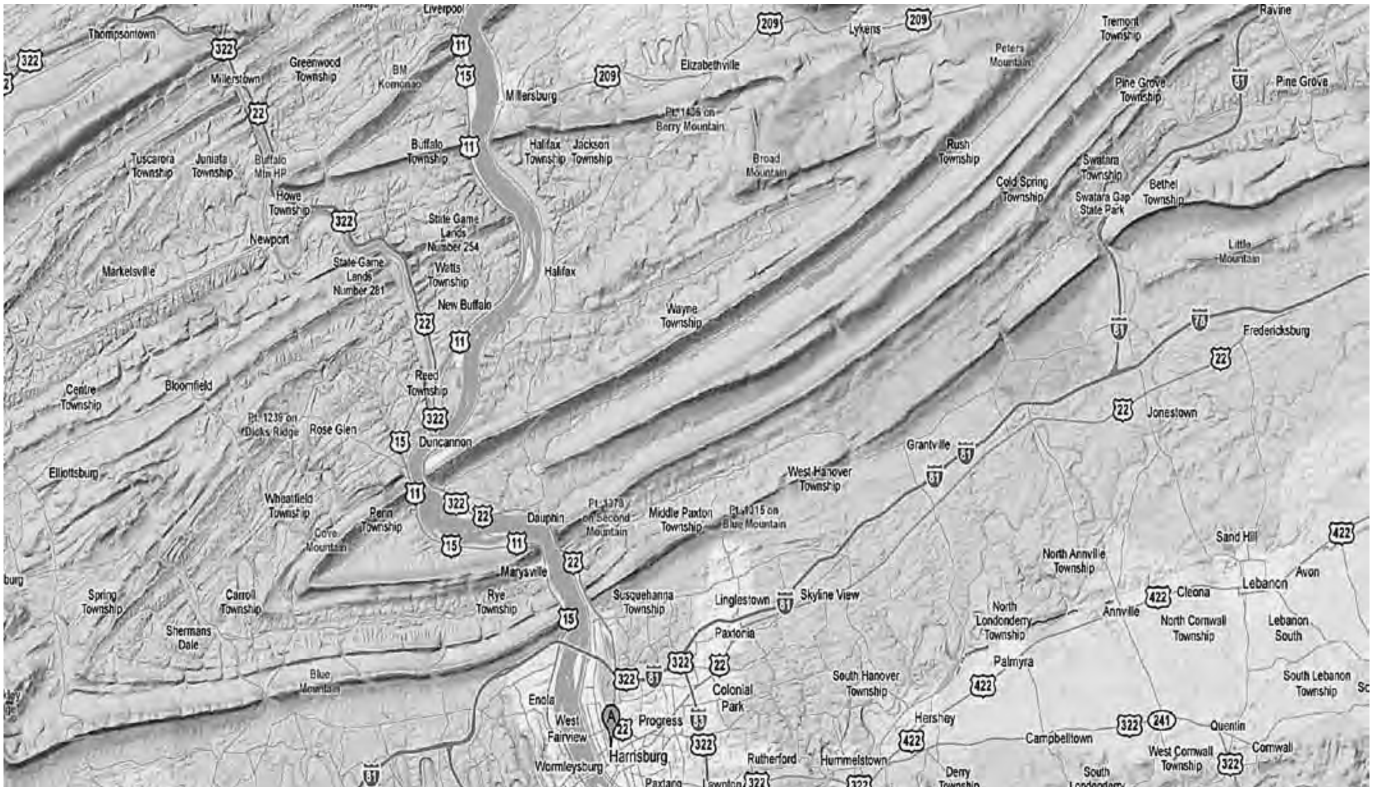

Figure 4. Google Maps Image of Susquehanna River water gaps north of Harrisburg, Pennsylvania. Note that the last two water gaps are aligned and the third to the north is almost aligned (© Google 2010).

The water gaps in the northern Appalachians start in the Valley and Ridge Province. One of the most famous is the series through which the Susquehanna River flows. The river cuts through the folded and eroded ridges of Blue Mountain north of Harrisburg, Pennsylvania (Figure 4). Blue Mountain is a linear mountain that stretches hundreds of kilometers northeast and is also called the Eastern Structural Front (Karle, 2009). Figure 5 shows the last water gap through Blue Mountain before the river flows out into the Great Valley at Harrisburg. Figure 6 shows the fifth water gap north of Harrisburg, seen at the top center of Figure 4. The Susquehanna River course is not influenced by the hardness or softness of the rocks (Short and Blair, 1986). The river, on the 37-km stretch upstream from Harrisburg (Figure 4), could have flowed around four out of five of the resistant ridges, had it followed the expected course at lower elevations over softer rocks (Strahler, 1945).

Ver Steeg (1930) listed 34 major water gaps in the northern Appalachian Mountains. Besides the Susquehanna

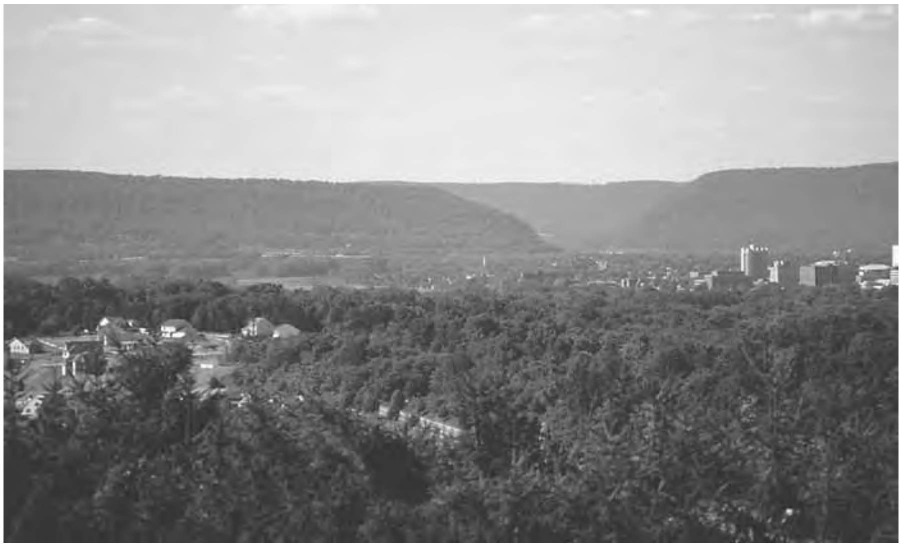

Figure 5. View north of the last water gaps on the Susquehanna River before entering the Great Valley at Harrisburg, Pennsylvania.

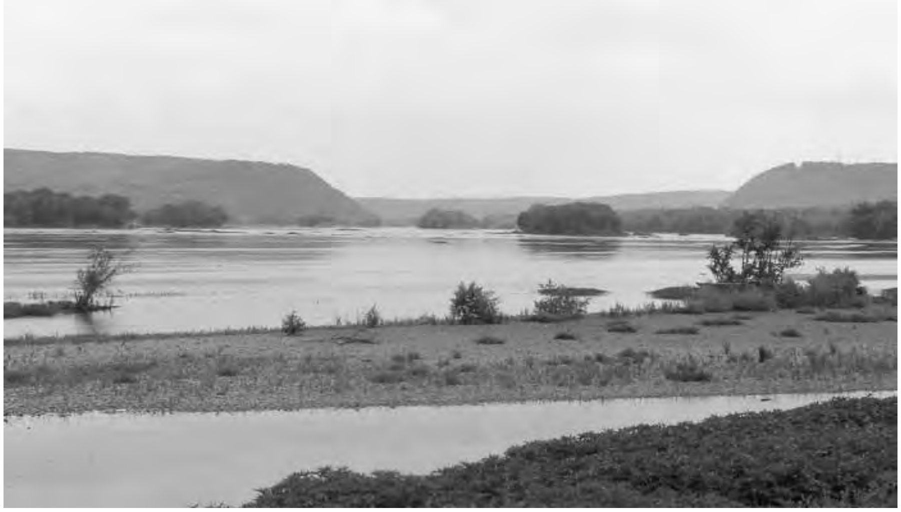

Figure 6. The fifth water gap north of Harrisburg, Pennsylvania, looking south.

River, the Schuylkill, Lehigh, and Juniata Rivers flow through major water gaps in various mountains or ridges. Another famous gap is the Delaware water gap (Figures 7 and 8) on the Delaware River through the Eastern Structural Front at the border of New Jersey and Pennsylvania (Karle, 2009). Interstate 80 follows this narrow, 365-m deep gap (Ver Steeg, 1930). Early geologists thought that it followed a transverse fault through the ridge (Strahler, 1945), but later research has discounted that hypothesis (Epstein, 1966). Karle (2009) showed that with vertical cliffs and talus slopes devoid of vegetation, the cliffs

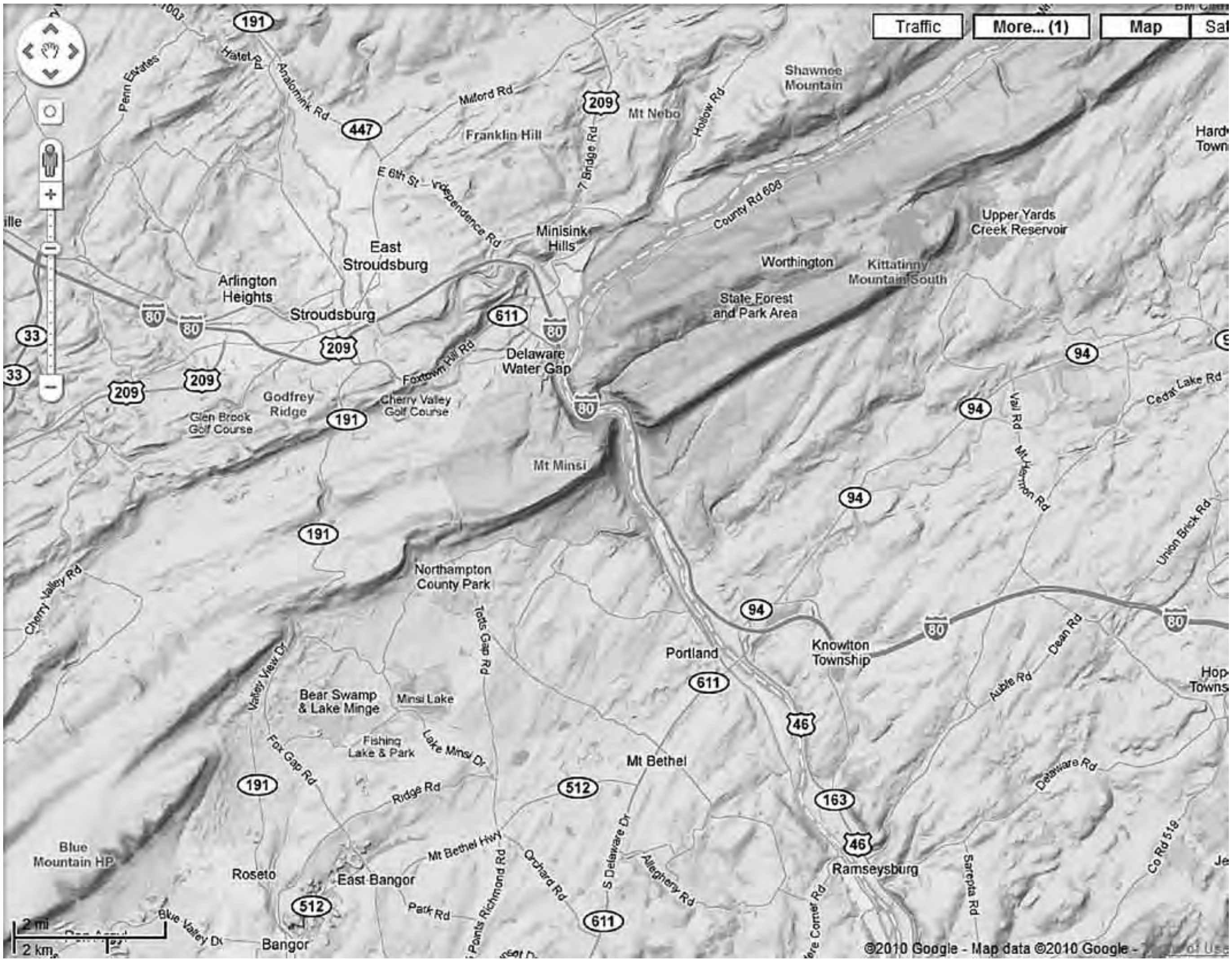

Figure 7. Google Maps terrain view of Delaware Water Gap.

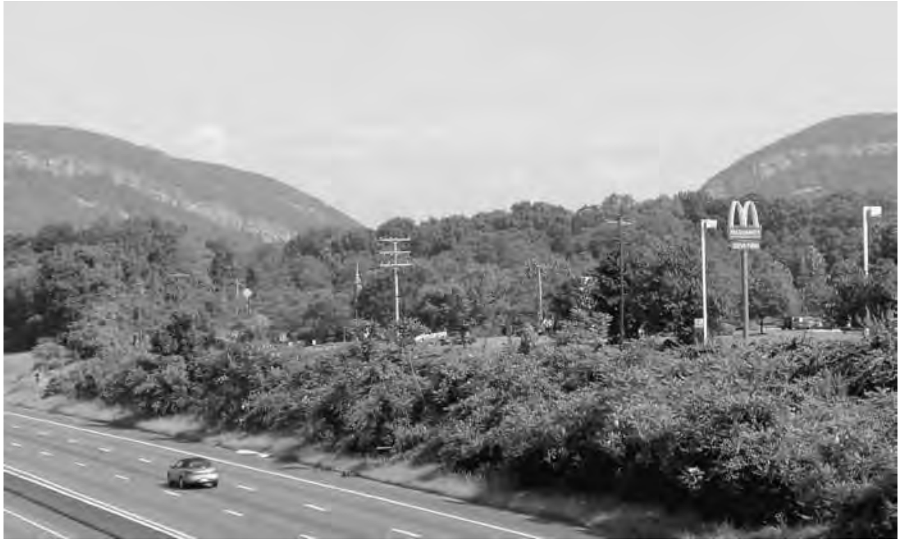

Figure 8. The Delaware water gap through Kittatinny Mountain (Eastern Structural Front) along the border of Pennsylvania and New Jersey, looking west from I-80.

around the Delaware water gap, as well as the Eastern Structural Front must be young features. Most water gaps in the Appalachians are erosional and cannot be attributed to faulting. In fact, many well-known faults have not resulted in water gaps (e.g., Strahler, 1945, pp. 46, 63–65).

In the central Appalachians, water gaps occur on the Potomac, James, Shenandoah, and New Rivers (Thompson, 1939; Fridley, 1939; Short and Blair, 1986). Harpers Ferry on the Potomac River is one of historical significance. The New River starts near the Blue Ridge Escarpment in North Carolina and cuts northwest through at least four ridges of the Valley and Ridge Province via major water gaps (Figure 9) (Bartholomew and Mills, 1991; Ward et al,

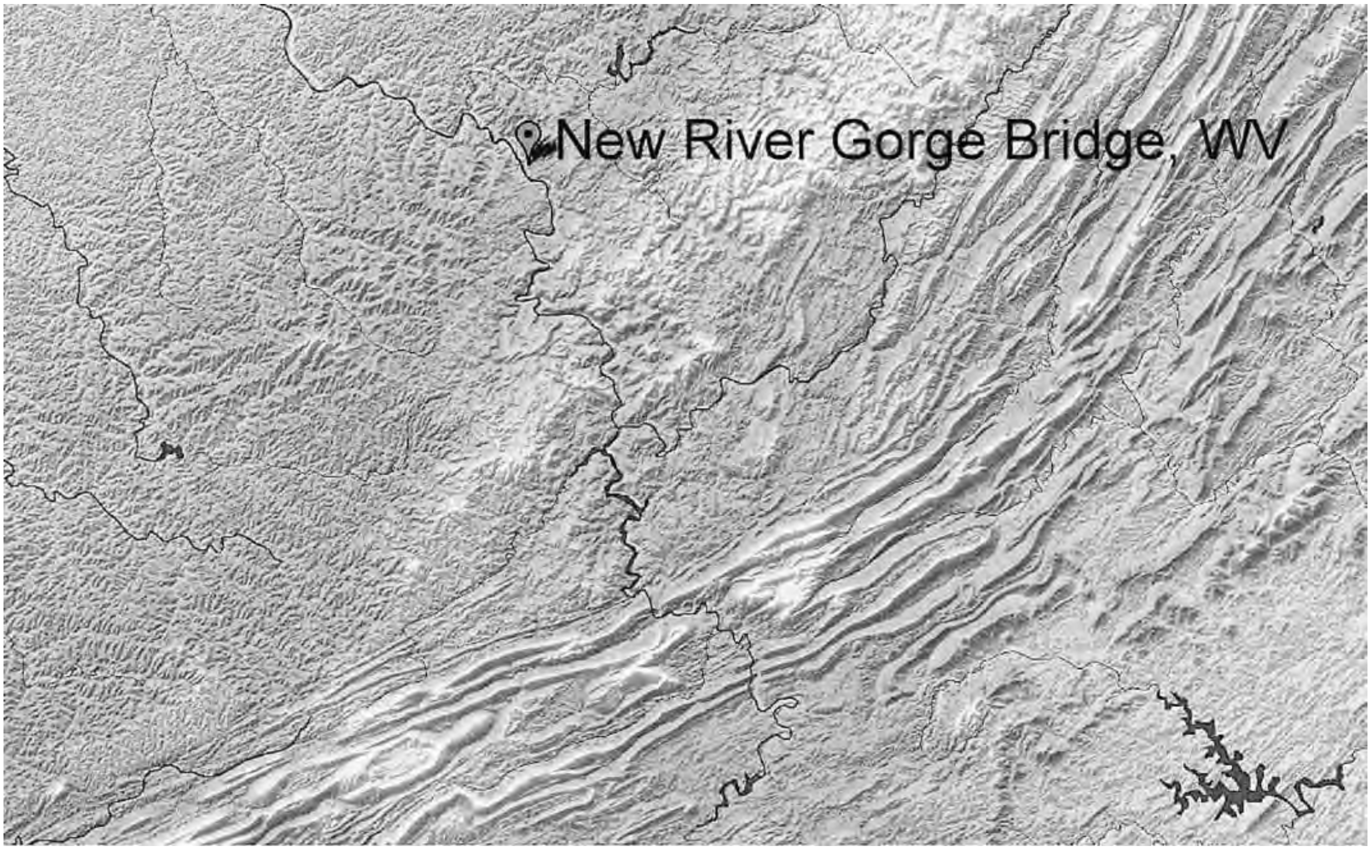

Figure 9. Shaded relief map of New River. Downstream toward top. Note that the river cuts almost straight through the Valley and Ridge Province (© Google 2010).

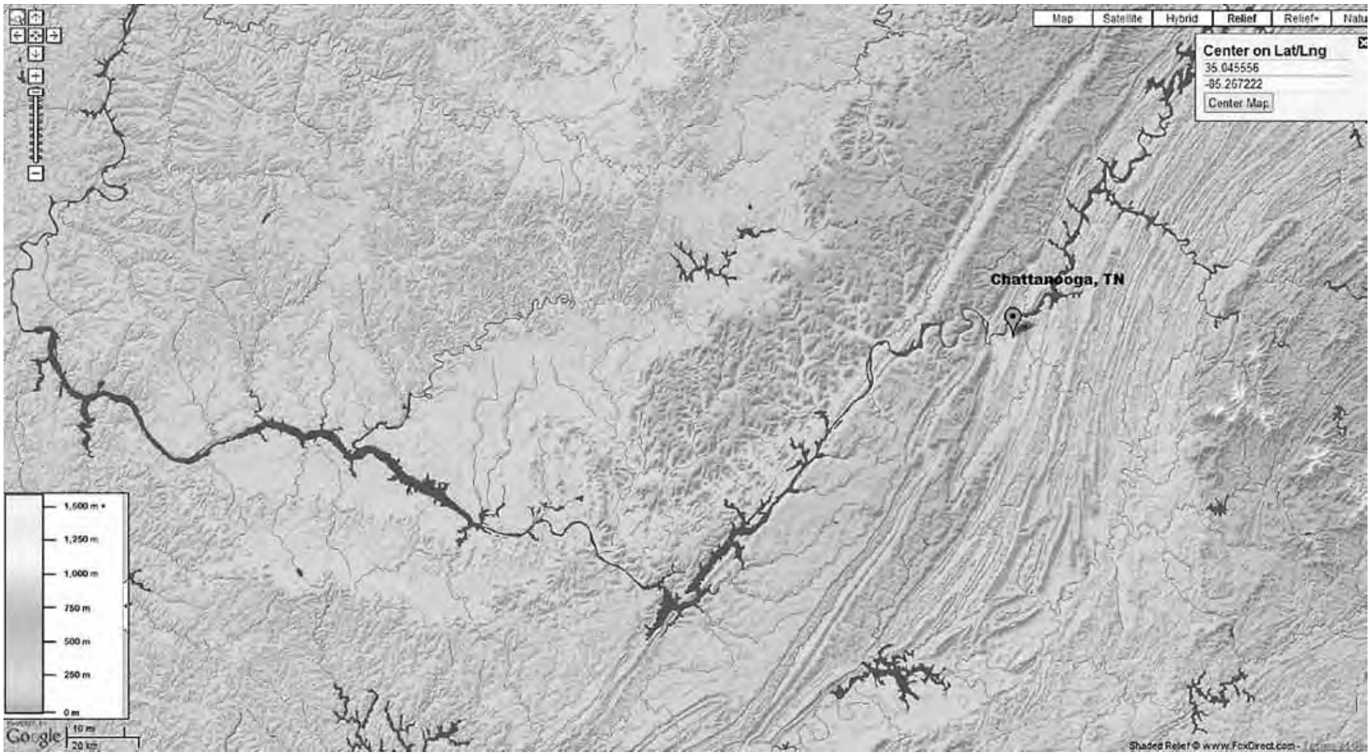

Figure 10. Shaded relief map of Tennessee River crossing Walden Ridge southwest of Chattanooga, continuing down Sequatchie Valley and cutting WNW at Guntersville (© Google 2010).

2005). Figure 18 of Part II of this series (Oard, 2011c) showed the 275-m deep New River Gorge at the New River Bridge, West Virginia.

Other enigmatic water gaps occur in the southern Appalachians. The course of the Tennessee River has always perplexed geologists. The river flows south down a valley of the Valley and Ridge Province for 400 km and instead of transecting a relatively low divide, 76 m higher, to the south, it turns southwest across the southeast Cumberland Plateau southwest of Chattanooga, Tennessee, through a 300-m deep "youthful" water gap (Figure 10) in Walden Ridge (Fenneman, 1938; Milici, 1968; Ollier, 1981; Williams and Akridge, 2005). A close-up view shows that the water gap is even meandering (Figure 11), an observation I have noted for other water gaps. The nearly flat-topped, relatively wide Walden Ridge lies between Chattanooga, Tennessee (Figure 12) and Sequatchie Valley (Figure 13). Figure 14 shows the Tennessee River within Walden Ridge. Had the Tennessee River followed the easiest course, it would have flowed south from Chattanooga, out onto the Piedmont of northern Georgia. Thornbury (1965, pp. 124, 126, brackets mine) stated:

> The abrupt change in direction of the Tennessee River southwest of Chattanooga, Tennessee, from a southwest to a northwest [actually south to a southwest] course, along with its gorge through Walden Ridge, has long puzzled geologists.

If that is not enough of a puzzle, the Tennessee River continues south down Sequatchie Valley for 120 km into northeastern Alabama, then turns west northwestward into northwest Alabama, and finally turns almost due north into higher terrain (Thornbury, 1965). It could easily be presumed that the Tennessee River would have continued south through Alabama to the Gulf of Mexico. Instead, it actually flows into the Ohio River at Paducah, Kentucky.

One of the most interesting aspects of the Appalachian water gaps is that multiple gaps are often aligned, as if the eroding current continued its course regardless of obstructions (Von Engeln, 1942). Even ridges and mountains could not divert the flow. This phenomenon occurs in both the northern (Strahler, 1945) and southern (Thompson, 1939) Appalachians. Figures 15 and 16 show two and three aligned water gaps through ridges in Pennslyvania. Figure 17 shows the two aligned water gaps at Harpers Ferry just after the Shenandoah River, coming from the south, joins the Potomac River, coming from the north.

Ver Steeg (1930) listed many wind gaps through the northern Appalachian

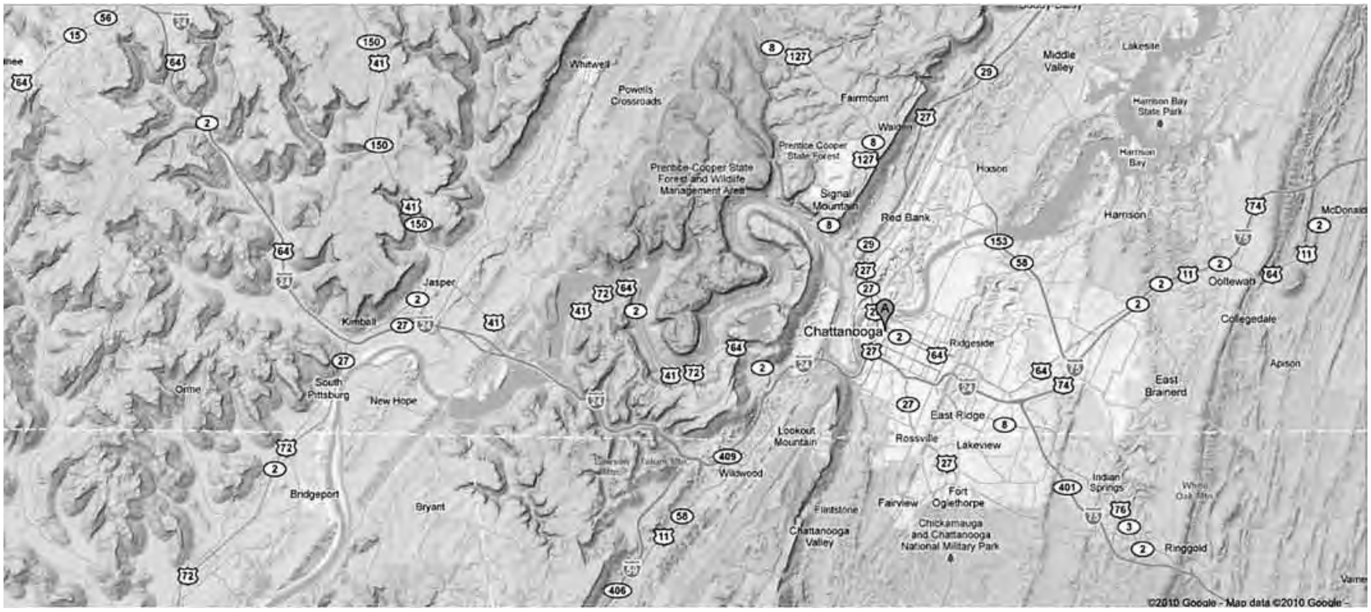

Figure 11. Google Maps close-up view of the meandering Tennessee River cutting through Walden Ridge southwest of Chattanooga. Note the flat tops of the Cumberland Plateau west of Chattanooga with the plateau much dissected, especially by the Sequatchie Valley running northeast-southwest just to the left of the center of the image.

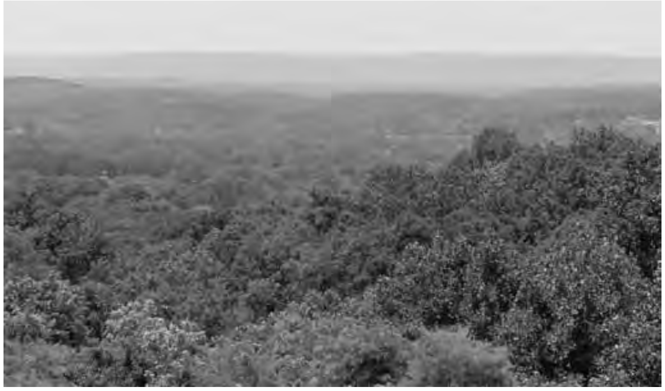

Figure 12. Walden Ridge, southeast Cumberland Plateau, view west across Chattanooga, Tennessee.

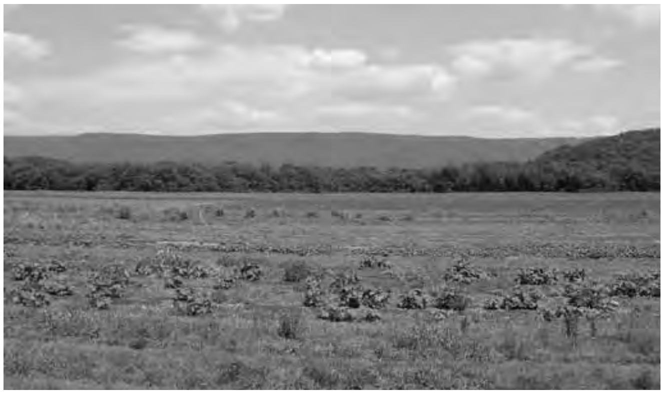

Figure 13. Walden Ridge, southeast Cumberland Plateau, view east from Sequatchie Valley.

ridges. Figure 18 shows a wind gap along Interstate 80. Figure 19 shows two wind gaps through the Valley and Ridge Province. The wind gaps occur at various altitudes, ranging from 220 to 520 m asl. Thompson (1939) described 161 wind gaps through the Virginia Blue Ridge alone. One of the more famous is the Cumberland wind gap on the border of southwest Virginia and southeast Kentucky (Figures 20 and 21). Early settlers passed through it on their way to Kentucky. It is nearly 185 m deep, as measured on the northeast side (Rich, 1933). Like the other Appalachian gaps, its origin is a mystery (see Thornbury, 1965, p. 145).

The anomalous drainage throughout the Valley and Ridge and Blue Ridge Provinces is a major geomorphological problem: "One of the major geomorphic problems of the folded Appalachians is the anomalous drainage, with transverse streams flowing across the structure, creating wind and water gaps" (Short and Blair, 1986, p. 56). Mills et al. (1987, p. 12) wrote that

> many master streams flow in deep gorges through ridges of resistant rock, with the Valley and Ridge

of Pennsylvania having the most dramatic examples. The problem of how streams were able to cut through such obstacles has fascinated many geomorphologists.

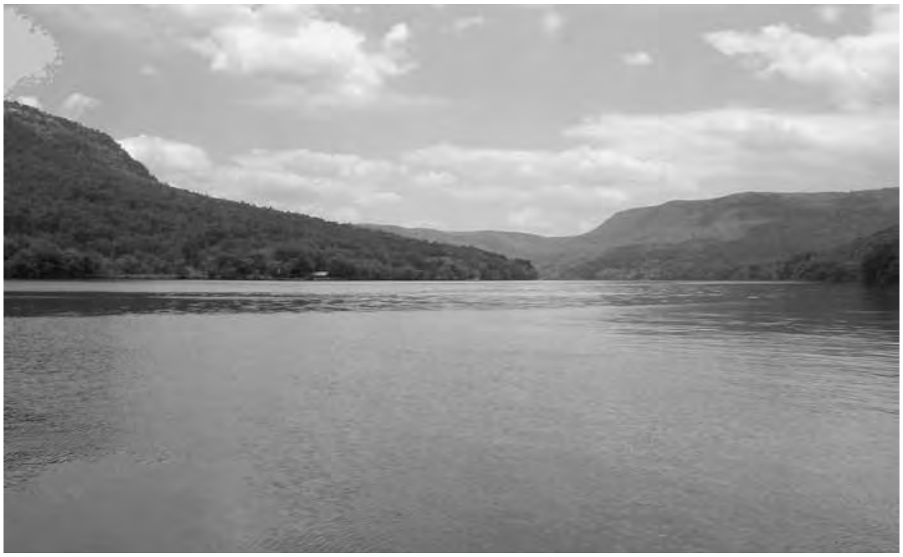

Figure 14. Tennessee River passing through Walden Ridge in a 300-m deep water gap.

Vertical Dissection of Plateaus

The Appalachian Plateau is severely dissected (Thornbury, 1965), with everything from minor valleys (Figure 22) to major 300–600-m deep river valleys (see Figure 11), such as on the New River in West Virginia. The eastern margin of the Appalachian Plateau has been especially eroded, creating the Cumberland Mountains on the southeast edge and the Allegheny Mountains on the northeast edge (see Part II, Oard, 2011c).

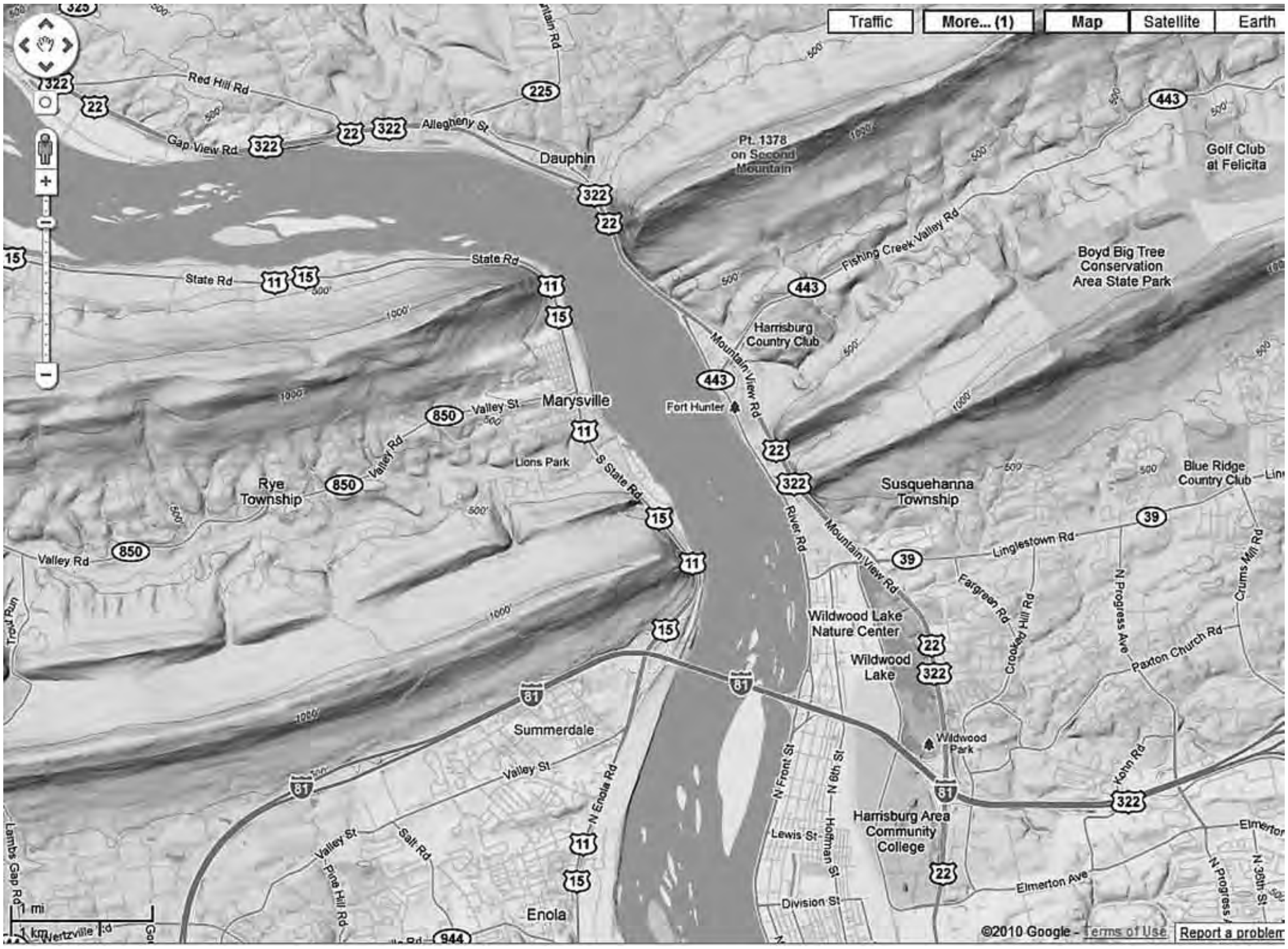

Figure 15. Google Maps close-up view of aligned water gaps of the Susquehanna River north of Harrisburg, Pennsylvania.

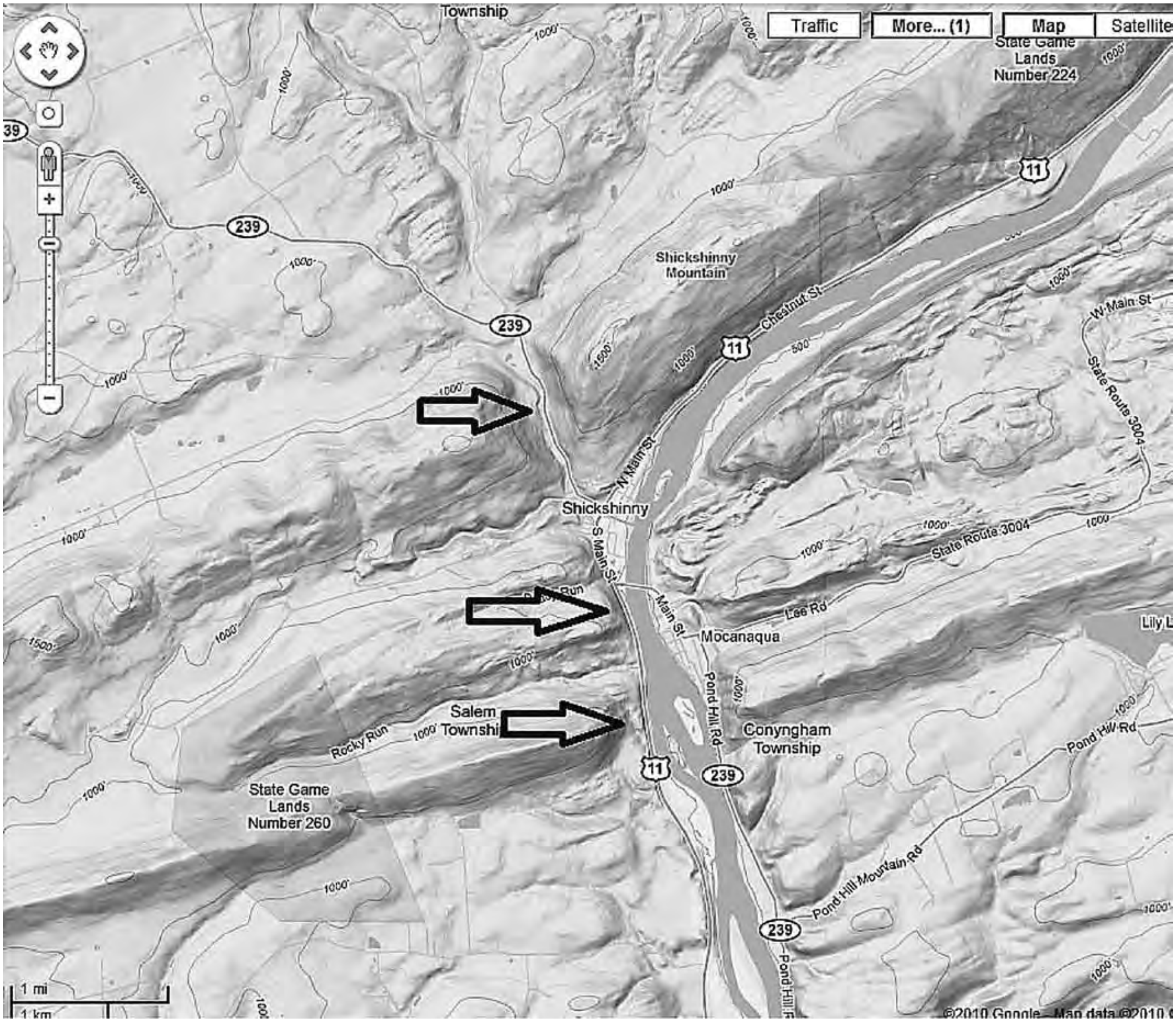

Figure 16. Google Maps view of three aligned water gaps (arrows) near Shickshinny, Pennsylvania. Note that the river passes through only two of them.

The rivers cutting the western plateau commonly have a second erosion surface along the sides called a *strath terrace* (see Figure 25 in Oard, 2011c). The Interior Low Plateaus Province to the west is also dissected but about half as much as the Appalachian Plateau Province to the east.

Uniformitarian Hypotheses and Problems

There are five uniformitarian hypotheses for the origin of water gaps, also called *transverse drainage* (Oberlander, 1965). Two of these, gaps as the surface expression of faults cutting through the mountains and William Morris Davis's relief inversion plus reversal in drainage, are not held today. That leaves three current uniformitarian hypotheses: (1) the antecedent stream, (2) the superimposed stream, and (3) stream piracy (Stokes and Mather, 2003, p. 76). The stream piracy hypothesis (Figure 3) has been locally suggested by a few early geologists (Adams, 1928; Fridley, 1939; Milici, 1968), but it is not considered

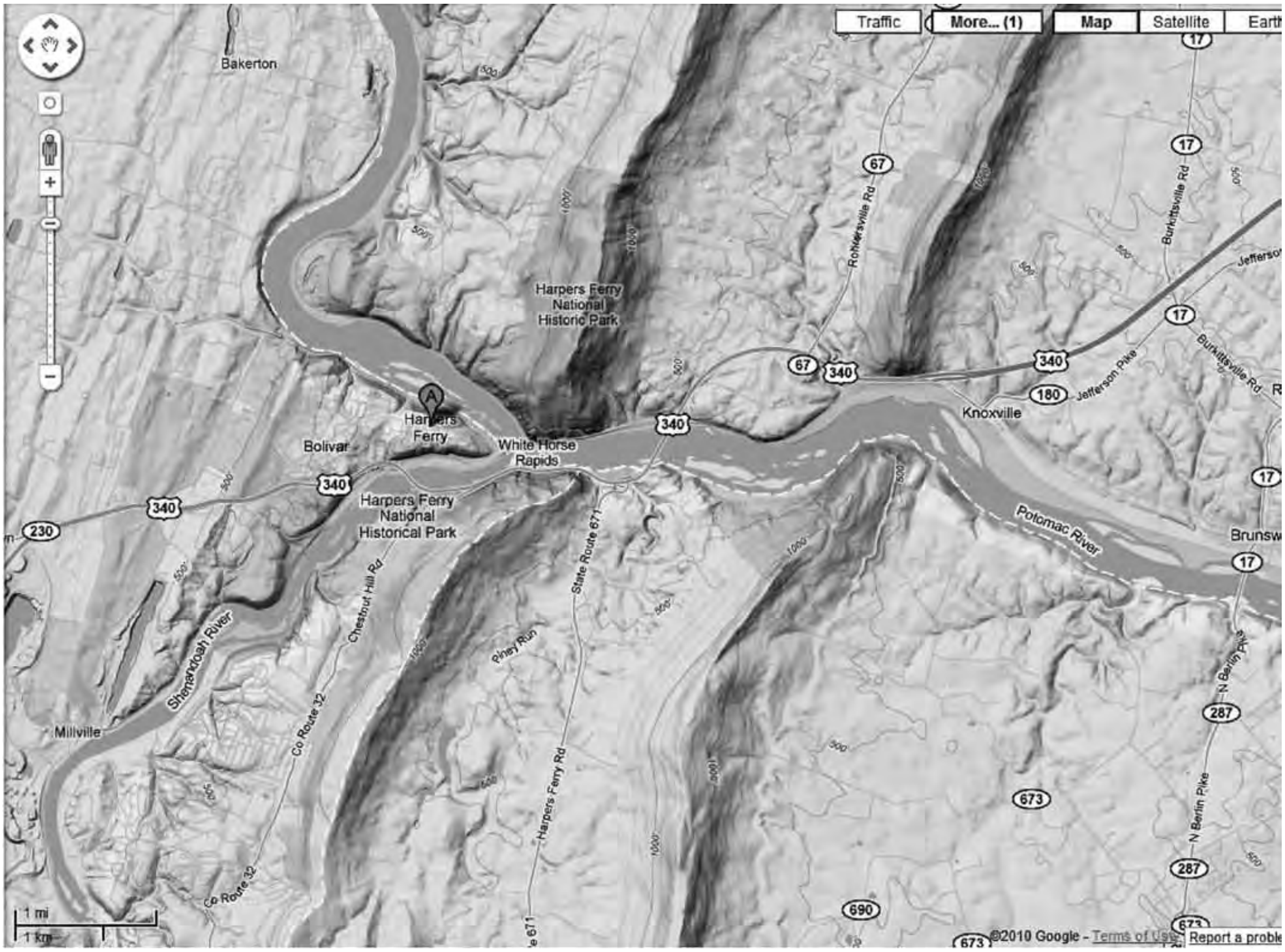

Figure 17. Google Maps view of aligned water gaps at Harpers Ferry, West Virginia. The Shenandoah River is coming from the south and joining the Potomac right at the gap—confluence of streams just upstream of gaps is not unusual.

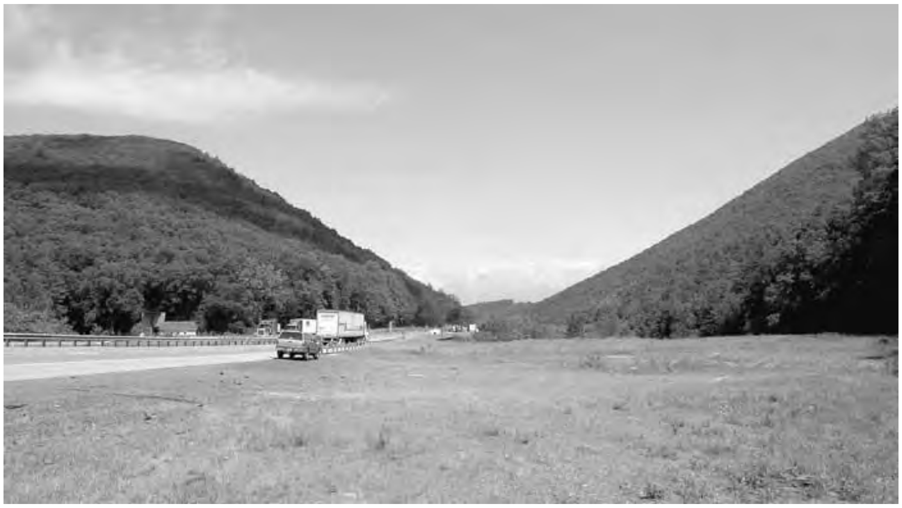

Figure 18. A wind gap through a ridge near milepost 251 on I-80 in Pennsylvania.

likely by geologists today (Clark, 1989; Morisawa, 1989; Strahler, 1945) and thus will not be discussed.

Antecedent Stream Hypothesis

The antecedent stream hypothesis, defined above and illustrated in Figure 1, seems to have been the first invoked to explain transverse drainage. John Wesley Powell simply *assumed* the Green River through the Uinta Mountains and the Colorado River through Grand Canyon had been eroded by antecedent rivers. Most other geologists accepted this hypothesis until the mid 1900s, when it ran into severe problems. Supposedly,

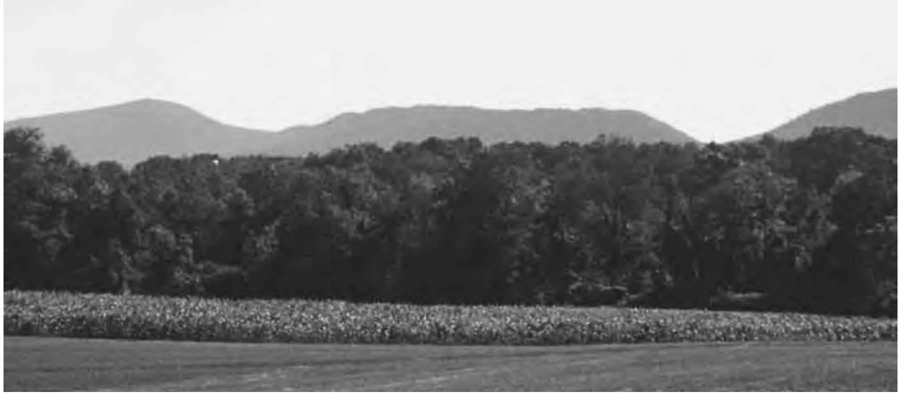

Figure 19. Two wind gaps through one of the ridges of the Valley and Ridge Province, looking southwest from Pennsylvania Turnpike, Milepost 204.

antecedence can be true only of large rivers since only they have enough erosive power to keep up with uplift (Ahnert, 1998). As noted above, some small tributaries in the Appalachian Mountains pass through water gaps.

Some investigators believe that river erosion would be slower than mountain building, thus eliminating this hypothesis from contention. Although Twidale (1976) disagreed, he admitted that antecedent rivers or streams are actually *rare*. Many water gaps once assumed to have formed by the antecedent stream hypothesis have been "reinterpreted" and attributed to other mechanisms, showing that there never was much evidence for the hypothesis to begin with. Its only strength is its contiguity with the uniformitarian or actualistic assumption.

In order to demonstrate antecedence, one must prove that the river in question predates uplift, but that is difficult (Twidale, 1976). Furthermore, uplift must be slow enough and steady enough so that the river's course is not deflected (Ranney, 2005). This represents a special conjunction of time and erosion—a major special condition that is not likely.

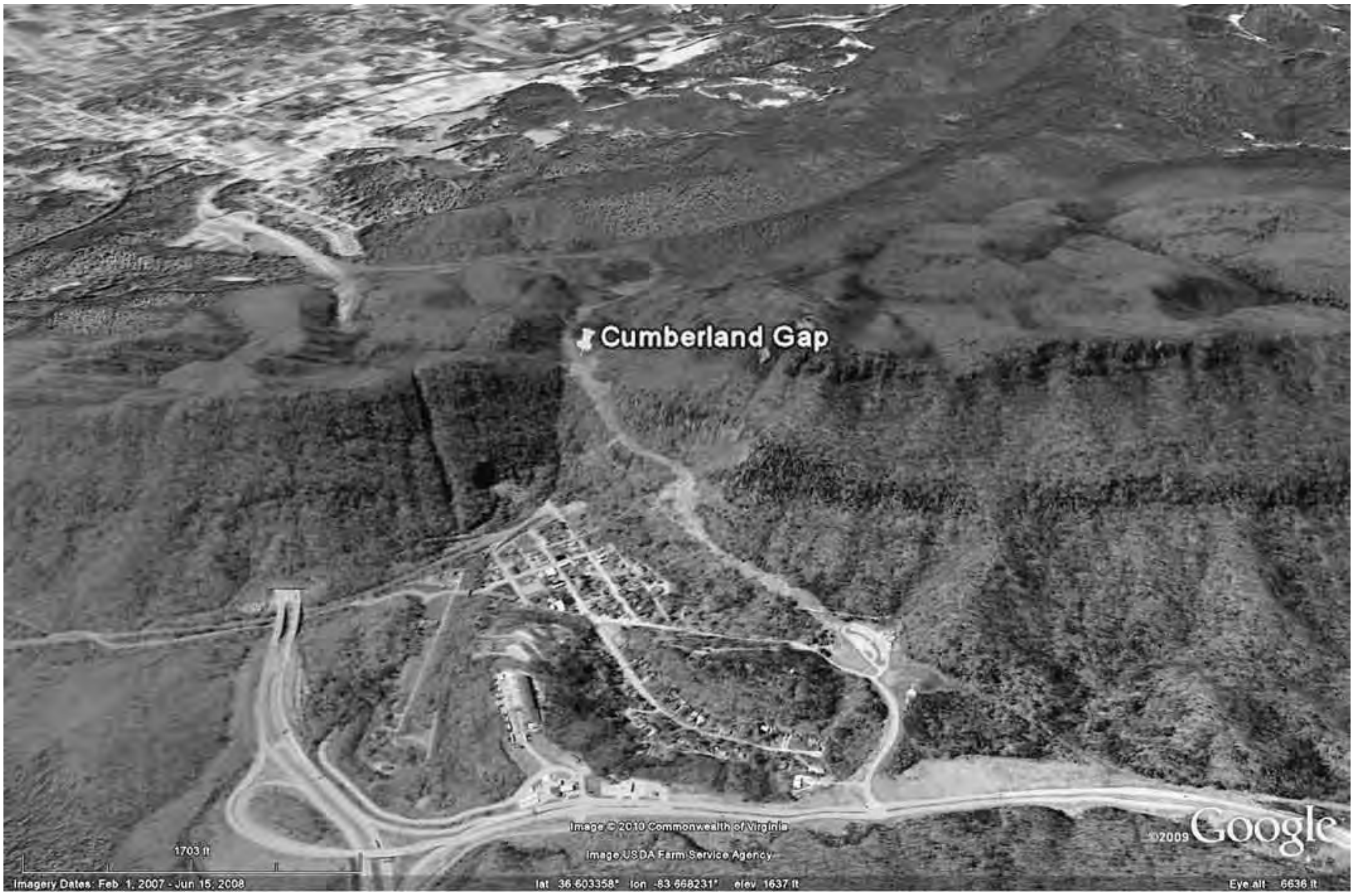
Cumberland Gap
Image © 2010 Commonwealth of Virginia
Image USDA Farm Service Agency
©2009 Google
1703 ft
Imagery Dates: Feb 1, 2007 - Jun 15, 2008
lat 36.603358° lon -83.668231° elev 1637 ft
Eye alt 6636 ft

Figure 20. Google Earth view of Cumberland Gap, no vertical exaggeration, looking northwest.

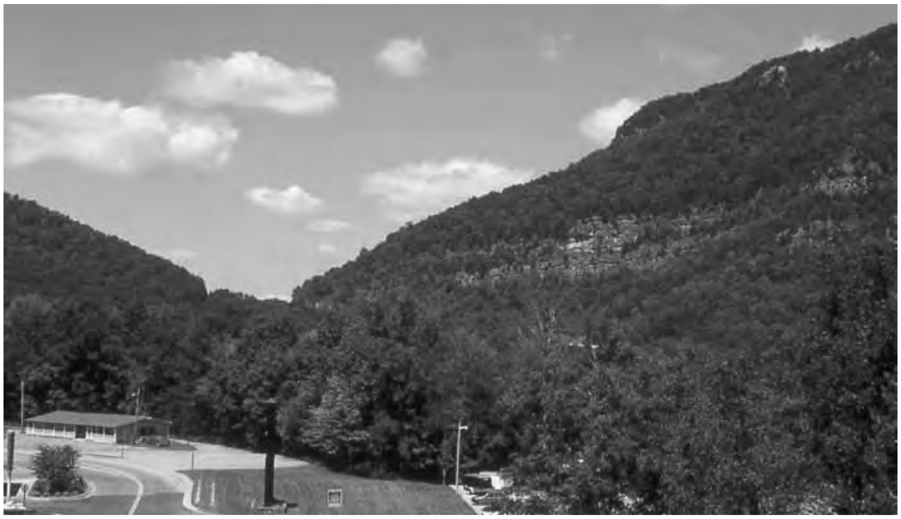

Figure 21. Cumberland wind gap on the border of Kentucky and Virginia, looking northwest.

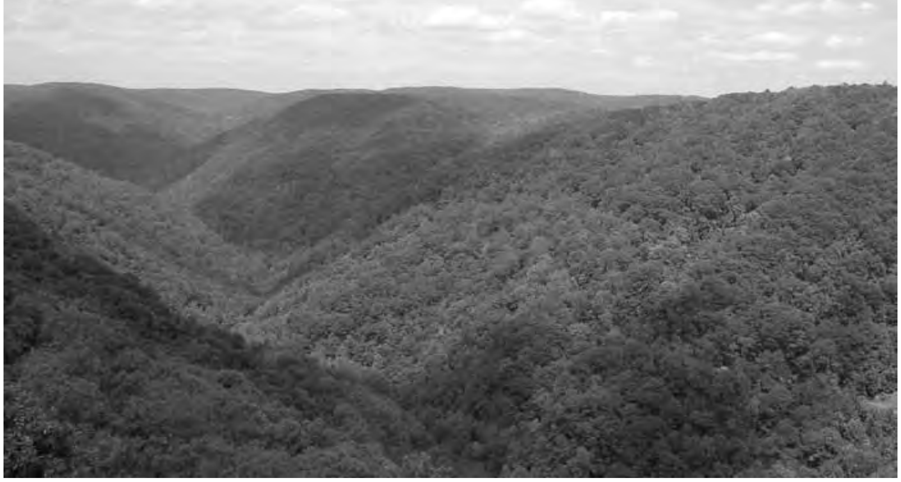

Figure 22. Dissected Allegheny Plateau at Glade Creek on Interstate 64 at Philip G. McDonald Memorial Bridge, West Virginia. The erosion surface is easy to see in the accordant summits of the hills.

Table I. Problems with the antecedent stream hypothesis
1. Now considered rare
2. Streams must predate mountain uplift
3. Must prove the mountains uplifted
4. Mountain uplift must be slow enough to not deflect the stream
5. Little if any lake deposits upstream caused by fast mountain uplift
6. Hypothesis rejected for many previously assumed antecedent streams
7. Aligned water gaps

If uplift was too rapid, a river in an enclosed basin would become a lake, and these deposits are rarely found upstream of barriers.

If a water gap through one barrier is difficult to achieve, aligned water gaps through multiple uplifts, such as on the Susquehanna north of Harrisburg (Figure 15), would be much less likely. The antecedent stream hypothesis appears to be a very simplistic explanation with little or no evidence, but it has been advanced when alternatives seem even more improbable (Small, 1978).

This hypothesis is rarely invoked. It is hard to even imagine how positive evidence could be adduced. Chorley et al. (1984, p. 21) confessed:

> In practice it is often difficult to assign a cause to such discordance; indeed, the type example of supposed antecedence, that of the Green River cutting across the Uinta Mountains in northern Utah, is now considered to be due, in part at least, to superimposition.

Actually, superimposition for the Green River is out also, so uniformitarian scientists are left with stream piracy, which cannot be demonstrated for this river either, or for any other river (Bishop, 1995; Douglas & Schmeeckle, 2007). Table I summarizes the difficulties with the antecedent stream hypothesis.

Superimposed Stream Hypothesis

In the superimposed stream hypothesis, a landscape is buried by renewed sedimentation, usually by a marine transgression. Then, a stream or river is established on the generally flat cover of sediments or sedimentary rock, called the "covermass." As erosion takes place over millions of years, the stream erodes downward in the same location (Figure 2). In that way, after millions of years, the stream ends up flowing through structural barriers. At the same time, the rest of the covermass not in the path of the river is somehow eroded or mostly eroded, leaving behind the stream or river flowing through ridges or mountains. Geomorphologists default to this hypothesis if they find any remnant of the so-called covermass or indirect evidence of its existence (Twidale, 2004). This is quite a stretch of imagination based on little evidence of a covermass.

Discordant drainage in the Appalachian Mountains was initially attributed to antecedent streams (Von Engeln, 1942), probably because it was the reigning idea at the time. However, superimposition later became favored (Strahler, 1945; Thompson, 1939), partly because the tops of the ridges are thought to define an ancient erosion surface (Short and Blair, 1986). If so, that surface would have been generally level, and rivers flowing across it were assumed to have cut down into older deformed sedimentary rocks. This is thought true only of large rivers; smaller flows are generally congruent with the structure (Kaktins and Delano, 1999). Ollier (1991, p. 33) noted that the major rivers were caused by superimposition while their tributaries were not:

> Classic examples of superimposed drainage are found in the Appalachian Mountains. Accordant levels of ridge tops show that the folded Palaeozoic strata were planated, and major rivers such as the Susquehana [sic] originally flowed across this plain regardless of structure. They have later been incised and now flow through superimposed gorges, but tributaries are strongly structurally controlled.

As previously mentioned, many tributaries do flow parallel to the ridges, but then they mysteriously jump across ridges through water gaps (Figures 23 and 24).

Von Engeln (1942) also pointed to the aligned water gaps as evidence of superimposition, since these features would not be likely caused by antecedence or stream piracy. Strahler (1945) saw two possibilities: superimposition and fault control. He left no room for stream piracy, and claimed that wind gaps were evidence of superimposition. William Morris Davis also believed that the Appalachian water and wind gaps were created by superimposition (Morisawa, 1989). His second cause of fault control has since been shown not to be the case for most Appalachian water and wind gaps, although some gaps could be caused by structural weakness (Clark, 1989; Epstein, 1966; Morisawa, 1989). Thus, the superimposed stream hypothesis seems to have been accepted by default, because of the insurmountable problems with alternatives.

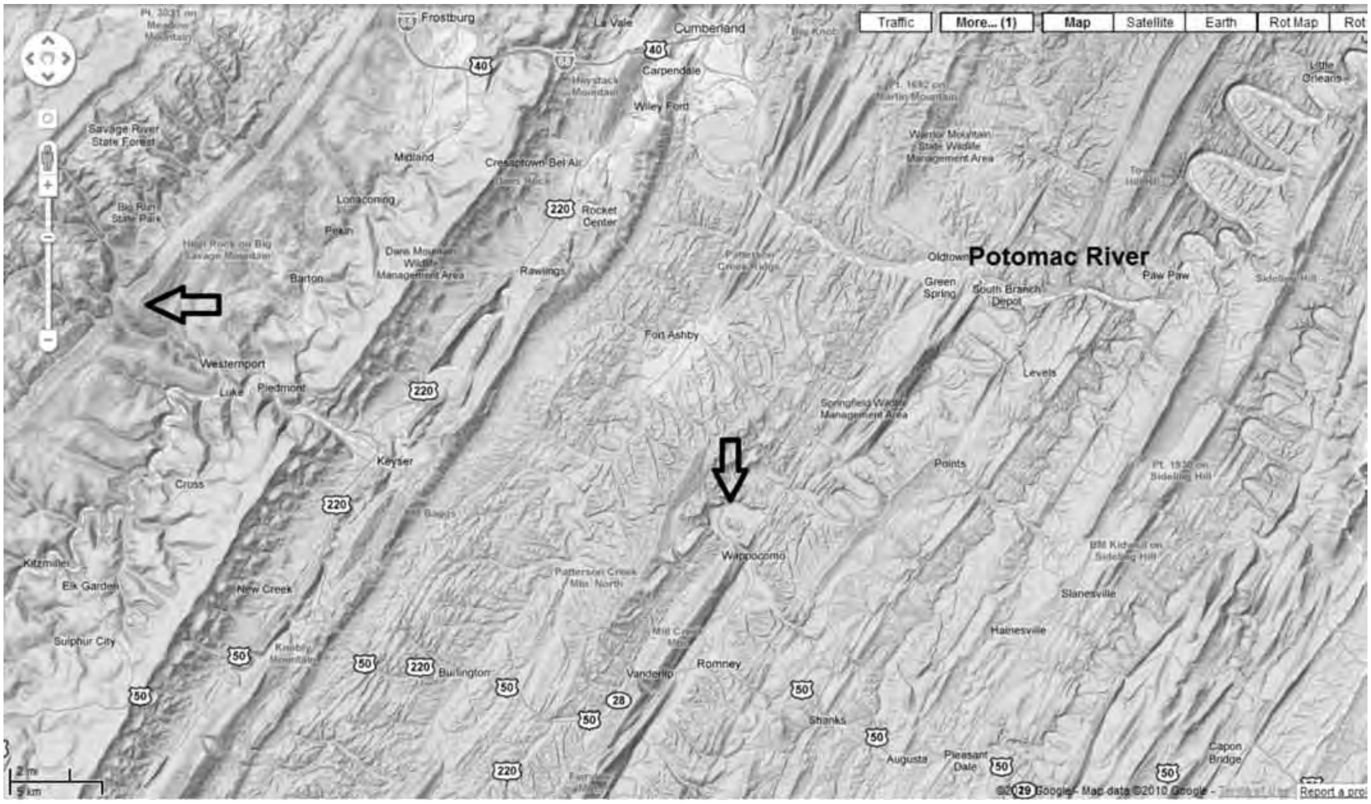

Figure 23. Google Maps image of two tributaries (arrows) of the Potomac River that generally flow parallel to ridges but then cross the ridges.

But this hypothesis has its own problems. Perhaps the most significant is the absence of evidence for the proposed transgression, the great volume of "covermass," and the "peneplain" prior to downward erosion by rivers (Mills et al., 1987). Kaktins and Delano (1999, p. 382) stated:

> Because Cretaceous marine deposits do not occur within the Appalachian fold belt, a subsequent episode of peneplanation was also required…. This proposal is seriously impaired by its reliance on both the questionable concept of peneplanation and the purely hypothetical Cretaceous marine cover.

Another difficulty is the tendency of modern rivers to take the path of least resistance. We would expect a downward-cutting river to change course as it encountered a more resistant anticline, and flow through the more easily eroded covermass. Finally, it is hard to adduce positive evidence for this idea, like the antecedent stream hypothesis. Mills et al. (1987, p. 14) summarized:

> As for superposition from an unconformable cover mass, there is no evidence of such a cover, and unlike in the ancient Appalachians, it is much more difficult to claim that the cover mass has been removed by erosion.

Ollier (1991, p. 33) also admitted there is no evidence for the Appalachian covermass:

> The age of the old planation is controversial, as is the former existence of a Cretaceous cover. The lack of any remnants of a Cretaceous cover makes the idea questionable.

Because of the lack of a covermass, Epstein (1966) rejected regional superimposition while accepting "local" superimposition.

On a larger scale, superimposition has a problem with removing the covermass in between the rivers. If the rivers are cutting vertically, then why would we expect laterally extensive erosion of these sediments on the ridges between the rivers? The hypothesis requires the river to maintain the *same* course and downcut into both resistant and nonresistant formations, while at the same time having the drainage basin erode the covermass all across the remainder of the region. Thus, the soft rocks are cut into valleys and leave the more resistant rocks as ridges, while the main rivers do not change course through the ridges (Crickmay, 1974). However, as seen in the highly dissected plateaus on the west side of the Appalachians (and elsewhere) fluvial erosion does not create level surfaces. And again, what evidence would we find to indicate that this had happened. The complete erosion of the

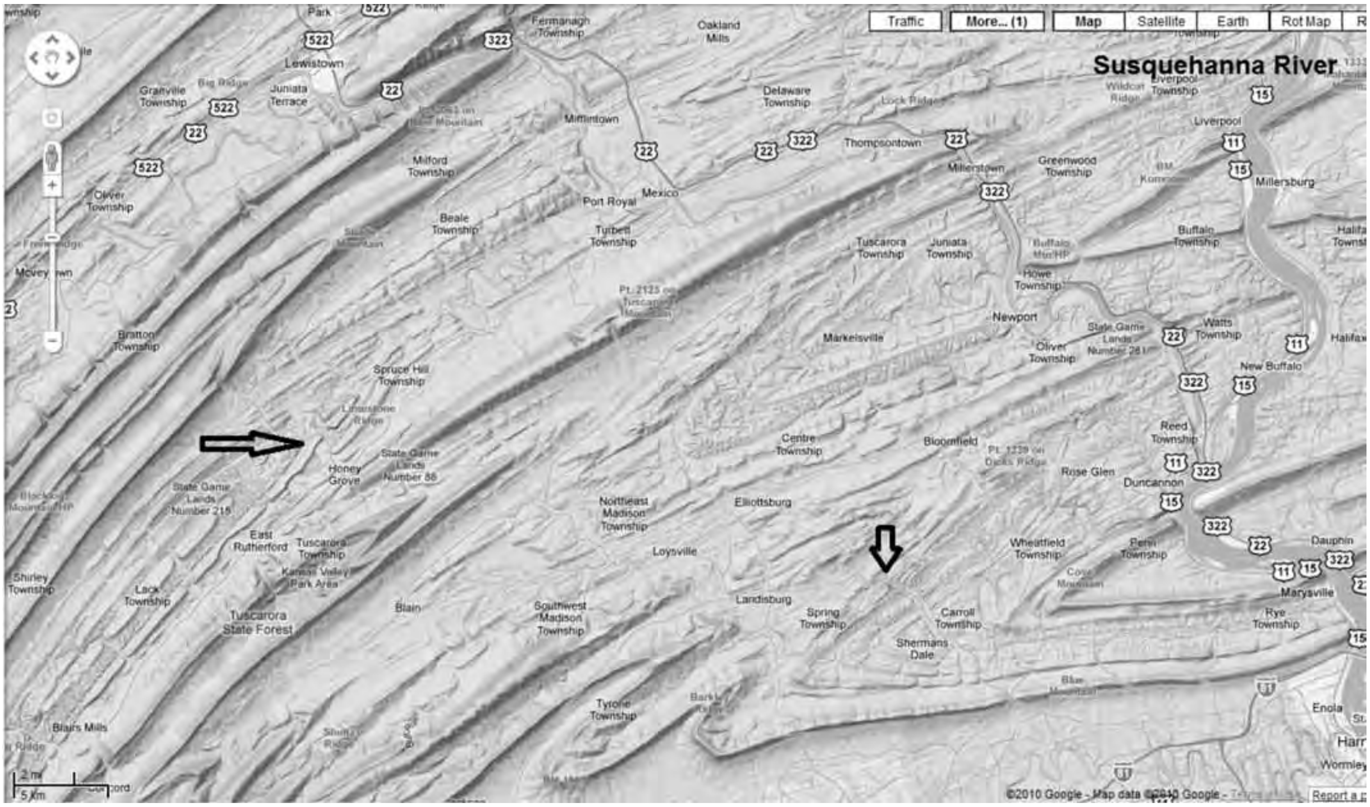

Figure 24. Google maps image of two tributaries to the Susquehanna River passing through water gaps.

covermass means that this is ultimately an argument from a lack of evidence:

> Although a plausible mechanism, superimposition is extremely difficult to verify except in the case of very young orogens [uplifted linear, folded, and deformed mountain belts] where vestiges of the original sedimentary cover remain. In ancient mountain belts, denudation will have removed all the evidence of any pre-existing sedimentary cover (Summerfield, 1991, p. 411, brackets added).

Even if a remnant of a sedimentary formation that once stood above the terrain can be found, one still has to demonstrate that the strata were once continuous and horizontal over a wide area, as well as having a covermass that is able to cause rivers to cut down through more resistant rocks. Table II summarizes the evidence against the hypothesis.

Table II. Problems with the superimposed stream hypothesis
1. Lack of evidence for a transgression of the sea and/or a covermass
2. Most, if not all, covermass eroded while rivers concentrate erosion linearly
3. Usually no evidence
4. Erosional remnants do not prove a covermass
5. In some cases, the covermass volume is huge and erosion must be great
6. Change in geological structure or lithology does not deflect the stream
7. Stream must maintain same course even after softer valley rocks eroded

All Uniformitarian Hypotheses Fail

In summary, none of the three major uniformitarian hypotheses are convincing for the Appalachian Mountains. This is also true for the thousands of water gaps across the earth found to date. Hack (1989) acknowledged that the origin of water gaps has not been explained, despite all the attempts. Uniformitarian geomorphologists seem to bounce from one hypothesis to another, stuck in the rut of their failed paradigm. However, they rarely present any evidence, much less compelling evidence. The only geomorphological cycle we see is the cycle through the failed hypotheses in desperate search of explanation.

Thomas Oberlander is a renowned expert on water gaps. He has many sobering thoughts on past and present research. For instance, Oberlander (1965, p. 1, emphasis and brackets added) noted the *conjectural* emphasis in explanations:

> The question of the origin of geological discordant drainage has almost always been attacked *deductively*, leading toward conclusions that remain largely within the realm of *conjecture*. Accordingly, the anomalous stream courses are attributed to previous tectonic environment [antecedence], to superposition from *hypothetical* erosion surfaces or covermasses, or to headward extension under largely *unspecified* controls [stream piracy].

Twenty years later, Oberlander (1985, p. 155, brackets and emphasis added) expressed the same opinion:

> Large streams transverse to deformational structures are conspicuous geomorphic elements in orogens [mountains] of *all ages*. Each such stream and each breached structure presents a geomorphic problem. However, the *apparent absence of empirical evidence* for the origin of such drainage generally limits comment upon it.

Then he stated (Oberlander, 1985, pp. 155–156, emphasis and brackets added):

> Transverse streams in areas of Cenozoic deformation are routinely attributed to stream antecedence to structure; where older structures are involved the choice includes antecedence, stream superposition from an unidentified covermass, or headward stream extension in some unspecified manner [piracy]. Whatever the choice, we are *rarely* provided with conclusive supporting arguments.

In regard to the Appalachian water and wind gaps, Clark, (1989, p. 225, 229) summarized:

> At this stage there are many facts, several hypotheses, but no single overall transverse drainage scheme that can be advanced as absolute … Still, lack of information on critical geochemical, geological, and geophysical datasets hampers further hypothesis erection and testing. Many of the same problems that dog the peneplain question (Seven et al., 1983, p. 161) also plague the unraveling of Appalachian drainage history. Is it any wonder that Craig (1979) could find no commonality of origin? What was written in 1932–33 [sic] can still be quoted today: "The Appalachian problem, like the poor, we shall have with us always." (Bryan et al., 1932/33, p. 318).

There has been little written on the origin of Appalachian transverse drainage problems during the past 20 years, so the problem is still a major mystery of Appalachian geomorphology.

If all of the classical uniformitarian hypotheses are insufficient, then we must conclude the necessity of searching for an explanation within a completely different paradigm. Ironically, the features of these landforms readily can be explained by the great nemesis of modern geology—the Genesis Flood.

Sheet Flow Transforms into Channelized Flow

Just as the sheet-flow phase explains the regional erosion surfaces and the deposition of widespread gravel lag deposits across these surfaces, the subsequent channelized-flow phase (Walker, 1994) is a logical answer to the problem of water and wind gaps. Water and wind gaps appear to be the last large-scale features formed by the Flood's recession off the Appalachians. As the sheet currents began to diminish into large embayments and channels, they would have still been flowing perpendicular to ridges (Figure 25a), initiating the water and wind gaps. The water and wind gaps indicate that the water was at first flowing perpendicular to the mountains when the Appalachian erosion surfaces were formed, since it takes perpendicular flow to create water and wind gaps. When the water and wind gaps were first started, the flow velocities would have been incredibly high, and locally variable (Schumm and Ethridge, 1994, p. 11). The water flow may have taken advantage of possible structural weakness or a low spot on the ridge. Epstein (1966) and Mills et al. (1987) believe some Appalachian water gaps started in zones of structural weakness. Regardless, initiated notches would have been carved along the ridge.

Once a notch was cut, water would have sought that channel, increasing flow velocity relative to the surrounding area (Figure 25b). The notch would quickly grow as more water was forced through the narrow opening. In addition, the faster water would have carried abrasive particles, cutting the gap even faster (Figure 25c). Fenneman (1938, pp. 198–199) noticed that the ridge tops are slightly lower around Appalachian water gaps, indicating decreasing current width during the erosion of the gaps.

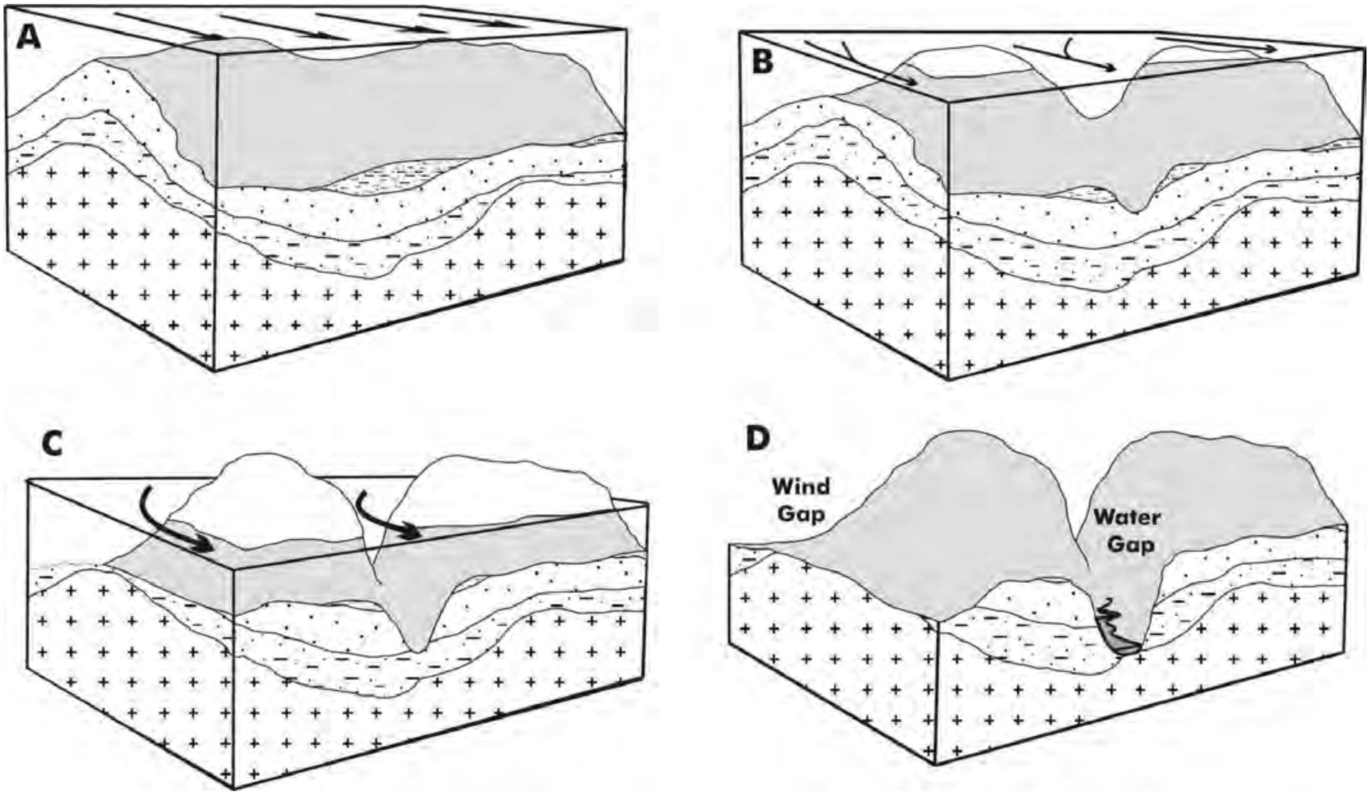

Figure 25. Series of schematics on the formation of water and wind gaps. Drawings by Peter Klevberg. (A) Water flowing perpendicular to a transverse ridge forms shallow notches on the ridge. (B) Notches eroded further as the water level drops below the top of the ridge. (C) Floodwater continues to drain as notches deepen. (D) Floodwater completely drained with a river running through the lowest notch, the water gap. Erosion ceased too early through the other notch, leaving a wind gap.

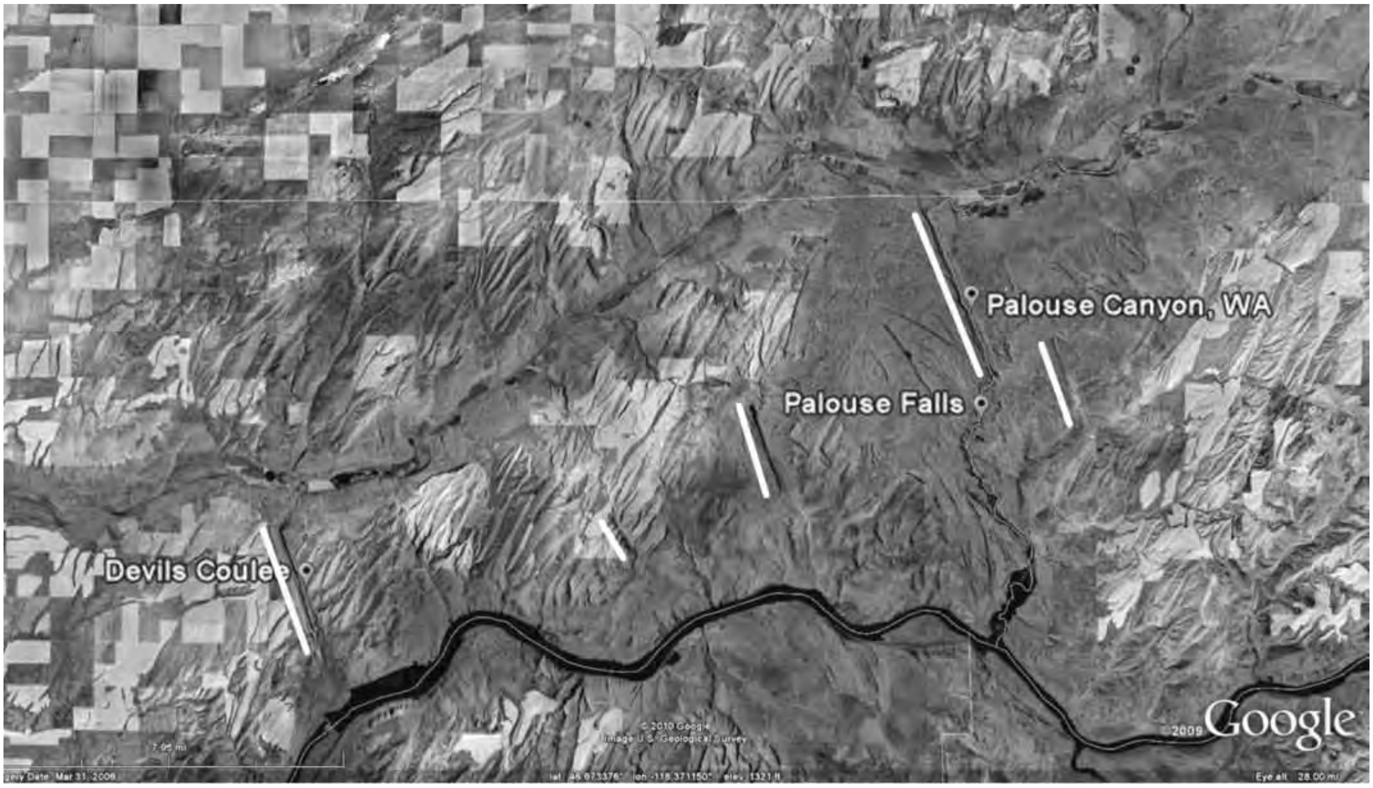

Figure 26. Goggle image of the ridge between Washtucna Coulee and the Snake River (lower center) showing where the Lake Missoula flood breached the ridge at generally four locations, but only two deep channels were cut through the ridge at Devils Coulee and Palouse Canyon.

While water and wind gaps were being formed, and the ridges become more and more exposed, the channelized flow would tend to also channel between the ridges, eroding the soft rocks. So, there would eventually be flow through ridges in the water and wind gaps previously formed and flow between ridges, as the water continued to drain toward the ocean.

The Flood explanation also differentiates between wind and water gaps. Wind gaps represent early water gaps that were left high and dry as the water level rapidly dropped or the current velocity diminished quickly, leading to the cessation of erosion (Figure 25c, d). These would have remained as remnants at high elevations while the lowering water carved new gaps at lower elevations, establishing the basic post-Flood drainage patterns. Today, only wind traverses the higher gaps, while the rivers naturally take advantage of the low water course through the water gap established at the very end of the Flood (Figure 25d). Changes in water level and velocity to stop the water flow through what are now wind gaps would have been caused by a variety of mechanisms, such as tectonic shifts caused by ongoing folding, current shifts, or diversion by rapid adjacent erosion.

This type of process is seen on a small scale in the breaching of an earth dam by water flowing over its top. Finding a zone of weakness, the sheet flow over the top rapidly cuts a narrow deep notch that channels the water through. Most of the remainder of the dam wall usually remains intact. Also, the anomalously high velocities and the scale of the channelized currents is the only feasible explanation for the phenomenon of *aligned* water gaps in a series of perpendicular ridges.

Crickmay (1933) stated that wind gaps have been modified little by weathering since they first formed. This is entirely consistent with the Flood explanation—the channelized-flow phase was the last event of the Flood and not that long ago. This "youthfulness" is also an argument against the actualistic model; we would have to accept that wind gaps have remained untouched by erosion for millions of years.

Water and wind gaps in the Appalachians show similarities to those in the western United States, such as those

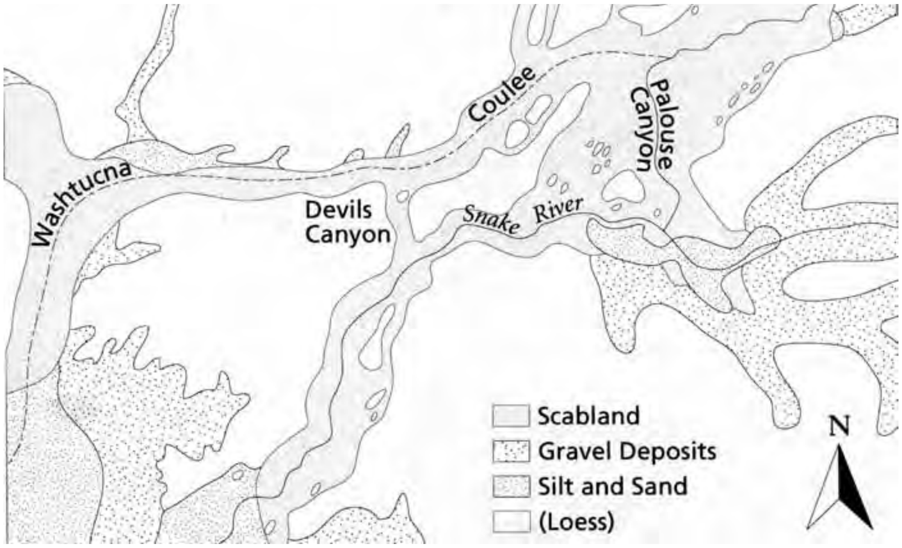

Figure 27. Map of ridge between Washtucna Coulee and the Snake River, showing Palouse Canyon, a water gap, and Devils Canyon, a deep wind gap, cut during the Lake Missoula flood. Modified from Bretz (1928, p. 205) by Mark Wolfe.

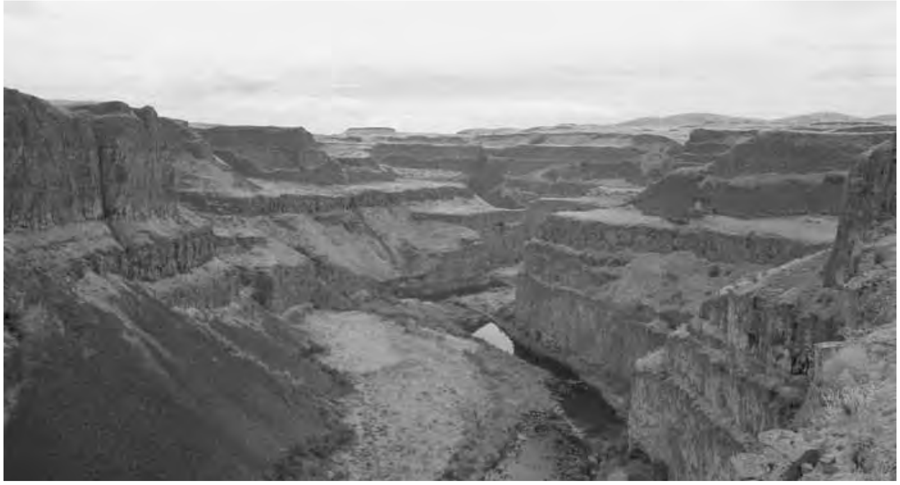

Figure 28. Palouse Canyon downstream from Palouse Falls

formed by the Lake Missoula flood at the peak of the Ice Age (Oard, 2003, 2004a, 2004b). The Lake Missoula floodwater rushed south into the head of Washtucna Coulee. It overtopped the ridge between Washtucna Coulee and the Snake River at generally four locations (Figure 26), forming a water gap and one deep wind gap (Figure 27). At the head of one—Palouse Canyon—its width was initially around 13 km, but the flow narrowed, cutting a vertically walled canyon 150 m deep—down to the level of the Snake River (Figure 28). Subsequently, the Palouse River, instead of continuing west down Washtucna Coulee as before, took a 90° left turn, flowing into the Snake River. Palouse Falls (Figure 29) is a remnant left from the canyon cutting and would represent a *knickpoint*.

Devils Coulee, 24 km west of Palouse Canyon, is a narrow notch 150 m deep that was eroded through the ridge (Figures 26 and 27). However, the current did not erode this coulee deep enough at its entrance from Washtucna Coulee. The entrance to Devils Coulee is approximately 30 m above Washtucna Coulee, and so no stream was diverted down it. Therefore, Devils Coulee remains a wind gap.

Palouse Canyon and Devils Coulee are examples of how large volumes of energetic floodwater perpendicular to a ridge can rapidly excavate water and wind gaps in hard rock (Oard, 2003).

Figure 30 shows two schematics of sheet flow transforming into channelized flow, forming water and wind gaps with the water being channelized more and more down the valleys and through developing water and wind gaps of the Valley and Ridge and Blue Ridge Provinces. The velocity of the water was likely enough to erode the bottom of the Great Valley into a linear erosion surface.

Summary

The Appalachian Mountains are a complex fold and thrust belt in the eastern United States. Several overlapping lines of evidence suggest that as much as 6.5 km of rock was eroded from the Appalachians during mainly Cenozoic uplift. At the same time, regional geomorphological features were formed. No actualistic hypothesis has been able to explain the geology and landforms observed. However, the retreating stage of the Flood, with its two phases, readily accounts for all of these features, including erosion surfaces, monadnocks, plateaus, and the many wind and water gaps cutting through the mountains along its entire length.

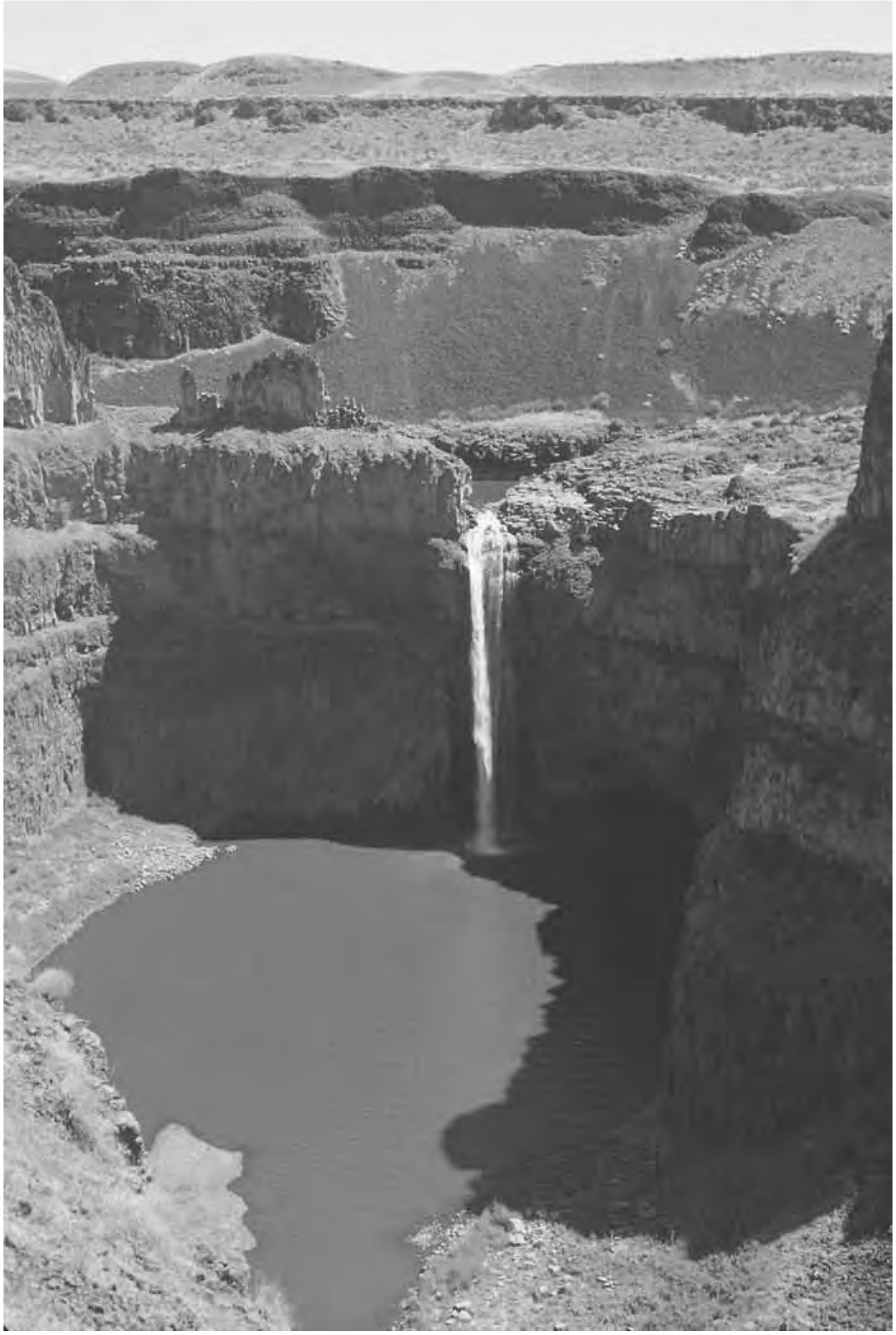

Figure 29. Palouse Falls on the Palouse River between Washtucna Coulee and the Snake River.

Sheet flow produced extensive erosion surfaces, mainly on the Piedmont and on the plateaus west of the Valley and Ridge Province. The extent and speed of these currents is evidenced by the extent and nature of the erosion, as well as by the gravel veneer deposited on top of the erosional surfaces. But the best way to visualize the energy involved is to understand that the shelf-slope system on the present continental margin was rapidly deposited from eroded Appalachian sediments.

As the combination of uplift and base-level decline caused the Appalachian Mountains to emerge from the Flood, the flow diverged from either side of the rising peaks. Sediments eroded west of the Appalachian divide were transported west, where they merged with water flowing east from the rising Rockies, carrying vast amounts of sediment that would form the massive Gulf of Mexico coastal plain and continental margin sediments. Erosion surfaces were later formed on either side of the Appalachian Mountains. As the Floodwater transformed from sheet flow into channelized flow, the erosion became narrow and linear. Valleys, canyons, and water and wind gaps would then be cut until the Flood ended. This is similar to the two-step erosion on the Colorado Plateau: (1) the Great Denudation from sheet flow, and (2) the Grand Canyon, Zion Canyon, and other canyons from channelized flow (Oard, 2010, 2011a).

Much of the erosion, the formation of erosion surfaces, and the cutting of water and wind gaps in the Appalachians are dated by secular scientists as late Mesozoic and Cenozoic. The deposition of the sediments along the coastal plain and offshore also occurred during this time. The pattern is typical of the retreating stage of the Flood seen elsewhere. It also indicates that the Flood/post-Flood boundary in this region corresponds approximately to the very late Cenozoic, assuming the secular geologic timescale.

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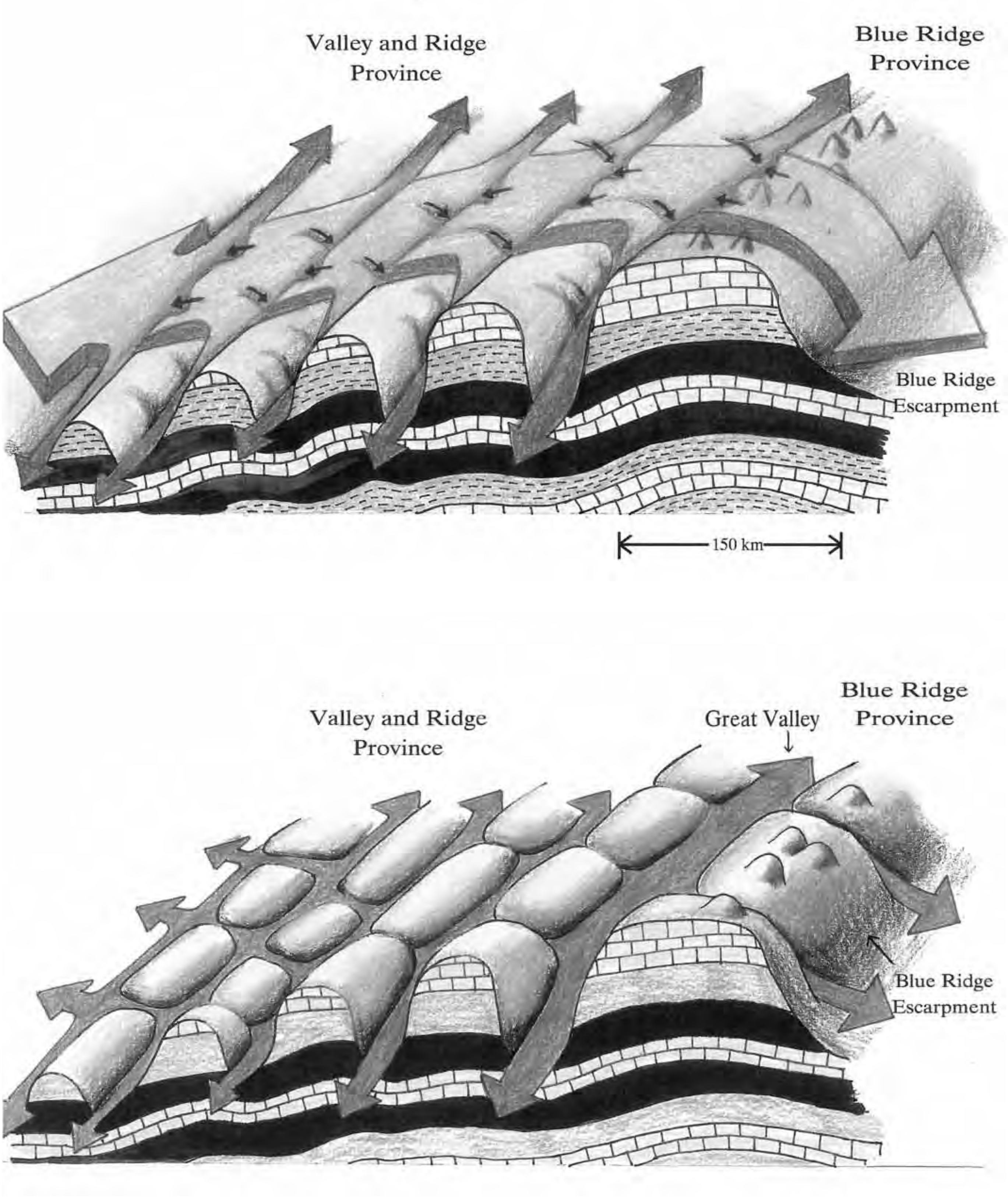

Figure 30. Big picture of the formation of water and wind gaps in the Appalachians. Drawing by Mrs. Melanie Richard. (A) Sheet flow transforms into channelized flow and starts to erode water and wind gaps. (B) Channelized flow drains down the valleys and across water and wind gaps of the Valley and Ridge and the Blue Ridge Provinces

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JofC: Journal of Creation, Technical Journal, or Creation Ex Nihilo Technical Journal

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Notes from the Panorama of Science

Transgression/Regression in the Grand Canyon

One of the most difficult problems in addressing questions is overcoming preconceived notions. This is true of the biologist who considers only evolutionary mechanisms, the sedimentologist who considers only present-day rates of erosion and deposition, or the Flood geologist who adheres only to one Flood model. Far too often, the most difficult part of dealing with any data is to let it speak for itself. This problem is illustrated by the relationship between the Tapeats Sandstone (Barnhart, 2012) and the transgression/regression of the Flood.

The Tapeats is a widespread, flat-lying sandstone deposited on the surface of the angular Great Unconformity in Arizona, and is thus the lowermost Paleozoic stratum in the Grand Canyon sequence (Figure 1). McKee (1945) proposed that it was deposited by a transgressive sea moving inland from the southwest, with sand being brought to the marine front by rivers flowing from the northeast. This basic concept was reiterated by Hereford (1977) and Rose (2006). Berthault (2004) took a slightly different view when he suggested an erosional transgressive invasion of water from the southwest, followed by deposition by the regressing current (analogous to a wave running up the shoreline and then receding).

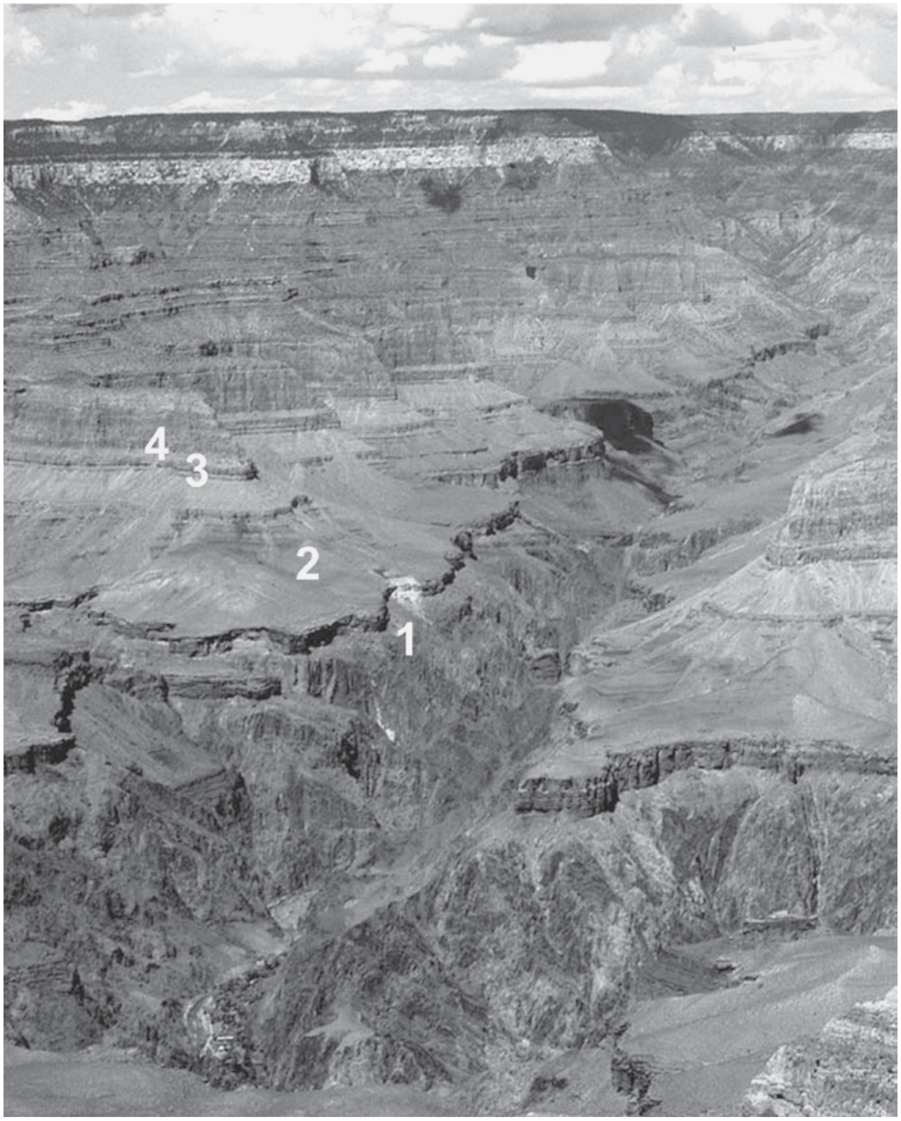

Figure 1. Overview of Grand Canyon showing Cambrian strata in context. 1 = Vishnu Schist, 2 = Tapeats Sandstone, 3 = Bright Angel Shale, 4 = Mauve Limestone. http://thevibe.socialvibe.com/wp-content/uploads/2009/01/arizona-grand-canyon-vista.jpg (accessed December 2010).

Many Flood geologists think this transgression marks the onset of the Flood. But we must be careful to assess the evidence. What about the Great Unconformity? This surface was formed by a major erosional event across the region. Barnhart (2011b) illustrates that it had to be a very rapid event, followed quickly by deposition of the basal Tapeats Sandstone. Another datum is the existence of small monadnocks on an otherwise nearly perfect peneplain (Rose, 2006). These occur in a linear trend from central Arizona through the eastern Grand Canyon (see Figure 2 of

Barnhart, 2012). They were attributed to the upthrusting of the Shinumo Quartzite of the Unkar Group by Hendricks and Stevenson (2003) because the quartzite is more resistant than the crystalline basement. But since some of the monadnocks are composed of other lithologies, erosional resistance may have had little to do with their formation. Some are composed of the soft Hakatai Shale, Garnet area (see figure 23 of Barnhart, 2012); the Vishnu Schist with intrusive Zoroaster Granite, east of Pipe Creek (see figure 7 of McKee, 1945); and Zoroaster Granite , Zoroaster Canyon (see figure 3 of Rose, 2006). Furthermore, Oard (2011, p. 113) noted that equal erosion of hard and soft material was a common characteristic of large planation surfaces: "such a feature requires a strong current of water." Unfortunately, the monadnocks below the Tapeats provide no information on paleocurrent direction of this "strong current of water."

However, evidence from the overlying Tapeats is abundant (Barnhart, 2012). The current depositing the Tapeats was from the northeast (Figure 2); see also Hereford (1977; see figure 6). Mathematical calculations—based on clast size, bedforms, and current velocities—suggest a flow depth of from less than one meter up to about 2.3 meters (Barnhart, 2012) and a paleoslope of 0.0014 to 0.0025, that is, only 0.08 degrees to 0.14 degrees, or essentially a flat surface. Given the widespread occurrence of the Tapeats, we must explain how a very shallow current over a flat surface over a large area could have maintained its energy. It is possible that it may have been a hyperpycnal flow, a submerged turbidity current (Lamb et al., 2010), gaining kinetic energy by gravity flow down from nearby highlands. The problem lies in the absence of evidence for the proposed highlands. The monadnocks are too low and too scattered to provide such energy. They did not even pose a substantial barrier to deflect the path of the current (see figure 3 of Barnhart, 2012).

With no evidence of adjacent highlands, the evidence of flow direction is found only in the paleocurrent indicators of the Tapeats. We cannot be sure of the direction of the current that eroded the basement or the origin of the body of water that supplied the sand. While it might be convenient to believe the Tapeats sand was deposited from the northeast into a rising body of water transgressing from the southwest, or the current transgressing from the southwest reversed and deposited the sand, or the eroding current was the leading edge of the Flood current transgressing from the northeast that later deposited the sand, these are all speculative. The only evidence now recognized is that the Tapeats sand was transported in a current from the northeast over a large, flat plain in very shallow, yet energetic, water. It might have coincided with a transgression or a regression of the sea, but that too is speculation.

This is one of the problems facing geological interpretation. We did not observe these past events; unlike modern situations, like Hurricane Katrina in New Orleans (Barnhart, 2011b), where depositional parameters were observed and could be related directly to sedimentary deposits, that information is not yet available for the sequence of events forming the Great Unconformity and the Tapeats Sandstone.

Models are good, but we must be careful to remember that they are only models. A correct model can lead to fruitful discoveries, but an incorrect model can lead in the wrong direction and obscure valid data, hindering research. Accepted wisdom is not always correct; catastrophism was rejected a priori by uniformitarians for much of the

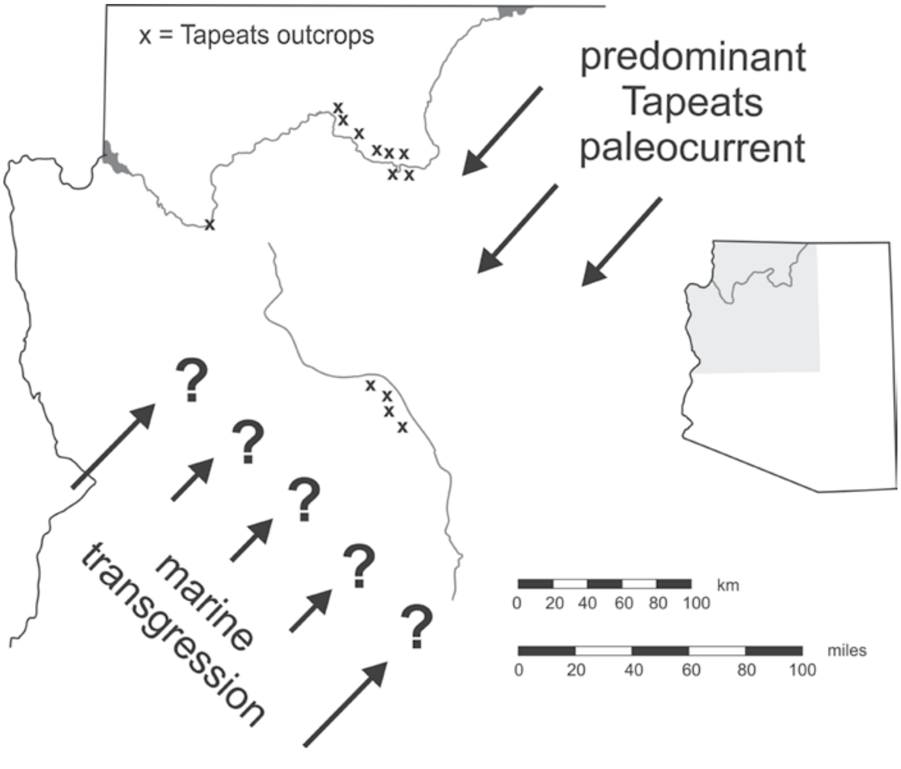

Figure 2. Known paleocurrent direction for Tapeats Sandstone and possible direction of marine transgression from southwest. X = selected Tapeats outcrops. Modified from Barnhart (2012).

history of geology. We must be careful not to repeat the errors of those we seek to correct.

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Letters to the Editor

The policy of the editorial staff of CRSQ *is to allow letters to the editor to express a variety of views. As such, the content of all letters is solely the opinion of the author, and does not necessarily reflect the opinion of the* CRSQ *editorial staff or the Creation Research Society.*

Bergman's Valuable Contribution

I want to thank Jerry Bergman for his insightful article on mature creation. I appreciated his balanced and biblical approach to the issues involved. Such an article is a very valuable contribution to the field of creation research at this time by clarifying the role of the supernatural in thinking about scientific inquiry.

I would like to further develop Bergman's discussion of arguments against the mature creation view. In particular, I would point out the importance of God's Word in assessing the validity of the theory, not just from a theological standpoint but also from a philosophical one. Bergman notes that some have argued that mature creation leads to the absurd notion that the universe could be any age, even two minutes old, and all of human history could simply be an "appearance of age." However, if biblical creation is true, then it follows that the Bible explicitly gives us the basis for rejecting such a notion, for if the universe were only two minutes old God would have explicitly deceived us in writing His Word. A written statement from God is of a distinct nature from chemical or electromagnetic information, no matter how important the latter may be to science. For God's written statement to be intentionally wrong is deceptive (Psalm 18:30; Romans 3:4); for chemical or electromagnetic information to give an appearance of age is not.

Some argue that if the heavens were created "mature" then the entire universe outside of our solar system would be nothing but a created lightshow. This is assumed to be deceptive in nature, since none of it would have actually "happened," and has led to the development of various theories explaining how the distant universe might actually be quite old while the earth is young (e.g., Humphreys, 1994). However, it is appropriate to ask how a universe created fully mature, including light beams traveling through space, would be deceptive, since there are no actual truth statements involved, only data. For example, the supernovae SN 1987A was not a deceptive "lightshow" on God's part to test our faith in a young universe but rather the natural outcome of a fully functioning, fully mature, *decaying* universe created with light beams *in situ*. To ask whether the supernovae "actually" happened is in some way to ask the wrong question, since from our perspective it *did* happen, and that fact allows us to learn about the universe and how it works, an evident result of creative design that would be lost if such events were not observed. Thus it would appear that the mature creation theory allows us to understand that the universe appears "old" in the sense that it is created complete. It is our responsibility to determine what indicators exist to show that it is young, i.e., created recently.

Thanks again to Dr. Bergman for raising these issues and for a stellar analysis of the problem.

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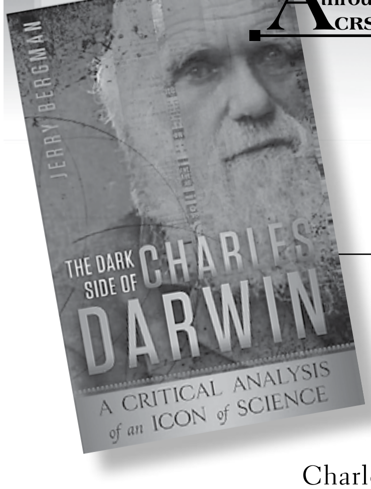
Media Reviews

Available through the CRS Bookstore


JERRY BERGMAN
THE DARK SIDE OF CHARLES DARWIN
A CRITICAL ANALYSIS of an ICON of SCIENCE

The Dark Side of Charles Darwin: A Critical Analysis of an Icon of Science

by Jerry Bergman

Master Books, Green Forest, AR, 2011, 270 pages, $14.00.

Charles Darwin (1809–1882) is often considered one of the most extraordinary biological pioneers of all time. The hagiographies written about him are numerous. Over the years, many of Darwin's false ideas have infected every part of society and contaminated disciplines that include politics, economics, education, religion, philosophy, and science.

In *The Dark Side of Charles Darwin*, Jerry Bergman copiously documents the real Charles Darwin few are willing to talk about. Darwin was a man, like all men, complete with spiritual flaws and darkness. From a biblical perspective, he was also a man loved by Christ. But for whatever reasons, Darwin rejected that truth and charted a life course that attempted to "un-Christ" the universe, denying the very Creator who loved him. In the end, rather than choosing Christ's glorious light, he chose darkness. Not only did he spend a lifetime suffering emotionally and physically, but his rejection of Christianity and pursuit of naturalistic explanations for the origin of life also proved (and still prove) to be a dead end.

This book is divided into four parts. In Part 1, Bergman discusses Darwin's views on creation and Christianity. Though Darwin seemed to have some belief in the Bible as a young man, he really did not spend a lot of time with it. His father and grandfather before him were probably agnostics, and maybe atheists at heart, but they tried to retain a semblance of religious toleration in keeping with society. His wife was a Unitarian and a believer in the Bible. Later in life, Darwin claimed agnosticism but rejected Christianity outright. Though Darwin claimed to be an agnostic, author Bergman makes the case that Darwin's belief in naturalism and natural selection were ways to explain life without a Creator. Therefore, the basis of Darwinist thought demands atheism. Ultimately, though Darwin claimed to be agnostic, he lived and wrote as though God did not exist.

In Part 2 Bergman discusses Darwin's mental health and whether he was psychotic. Throughout his adult life, Darwin suffered from "severe depression, insomnia, incapacitating anxiety, fits of hysterical crying, depersonalization, vision alterations, (... visual hallucinations), malaise, vertigo, shaking, tachycardia, fainting spells, shortness of breath, ... and sensation of loss of consciousness and impending death" (p. 87). In all, there were more than 33 psychological or psychologically influenced physical health problems that Darwin suffered from. These problems are vividly described in Darwin's own writings and are important to evaluate if we are to understand the man and his ideas. In chapter 6 Bergman makes the case that some of these health problems were connected to his conflicts with theism. Darwin "likely had much guilt over his theory [of] ... 'murdering God', by destroying the major reason for belief in God" (p. 107). In chapter 7, the discussion of Darwin's mental health is examined in the light of his sadistic lust for killing animals in large numbers. Though this bloodlust worried those close to him, Darwin admitted later in life that this behavior was abnormal.

Part 3 explores the question of Darwin's true scientific abilities. For example, it has been demonstrated by many authors that most of his ideas are found in earlier writings, including his grandfather Erasmus's tome, *Zoonomia* (1794). The question of whether Darwin plagiarized his work is examined in the light of why he seemed to resist giving credit where credit was due. His scholarship has also been brought into question, because in many instances his work was fraudulent, unethical, and just plain sloppy. Chapter 10 discusses his thoroughly refuted pangenesis theory.

Part 4 convincingly argues the case that Darwin was both a racist and a sexist. With regard to racism, Darwin's own words would be regarded as racist today and they were used to promote and exacerbate the racial problems that ensued in the twentieth century. He not only inspired the eugenics movement, but many family members turned out to be leaders of the movement, including his cousin Francis Galton (who coined the term "eugenics") and Darwin's sons, Leonard, Horace, Francis, and George. Though Darwin was not a believer in active (or forced) eugenics, which inspired men like Adolph Hitler, he believed in passive eugenics, or the idea that the weak in body or mind should choose to refrain from marriage so that their traits are not passed to the next generation. As for women, he viewed them as lower on the evolutionary scale and both biologically and intellectually inferior to men. His writings would play a major role in the development of this attitude in Victorian society

As a former Darwinist, I wish a book like this had been out during my formative years. It would have saved me some of the very painful transitions involved with changing worldviews. I had been weaned on neo-Darwinism for 20 years, but the emotional and intellectual pain of exchanging my naturalistic worldview with the more biologically satisfying and life-changing view of Christ, the Creator, was worth it. *The Dark Side of Charles Darwin* is a book that anyone interested in origins or the real Charles Darwin should have on his or her bookshelf. In the light of what we know today, the book shows how Darwin's ideas have been found wanting. Bergman helps us to understand, and have empathy for, the real Charles Darwin. He was a person, like the rest of us, who experienced weakness, pain, and a stubbornness to be independent of God. This book also challenges the naturalistic philosophies that continue to monopolize and infect all aspects of society, especially in the venues of world politics and academia. Fortunately, there are viable, biological alternatives to the dead end of philosophical naturalism.

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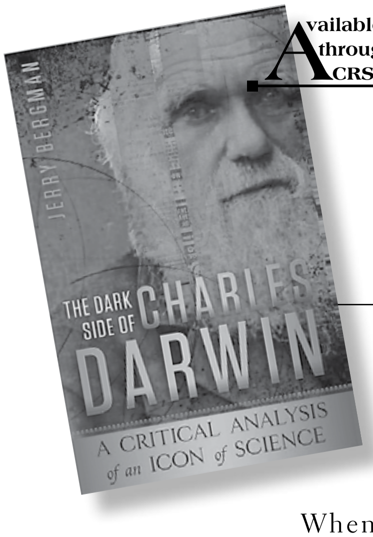
JERRY BERGMAN
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THE DARK SIDE OF CHARLES DARWIN
A CRITICAL ANALYSIS of an ICON of SCIENCE

Available through the CRS Bookstore

The Dark Side of Charles Darwin: A Critical Analysis of an Icon of Science

by Jerry Bergman

Master Books, Green Forest, AR, 2011, 270 pages, $14.00.

When Jerry Bergman debated arch-evolutionist P. Z. Myers in November 2009, the most dramatic reaction of the ideologically mixed crowd of about 500 came when Dr. Bergman suggested a connection between Darwin and Hitler. The reaction was a sustained growling noise. Further interactions on that topic in e-mails and on Dr. Myers's famous blog www.scienceblogs.com/pharyngula--a sort of literary "Jerry Springer Show"—indicates that no amount of data will allow such a sacrilegious conclusion among the faithful.

Jerry Bergman, with his characteristic thoroughness, has systematically dismantled the glowing reputation of the man often cited as the most important scientist of all time. But, of course, it will not be enough to sway those whose powers of yarn spinning are regularly exercised in the defense of evolution itself. In fact, in an uncanny manner, evolutionary thinking has taken on the form of Aristotelian scholasticism that was challenged by Francis Bacon when he argued for deductive reasoning from the data instead of inductive conclusions from authority. Now Darwin is the authority, and since "evolution is true," any apparent discrepancies must eventually and inevitably be solved. Also, as Galileo's descriptions of craters on the moon—in the perfect heavenly sphere—were unthinkable to that cosmology, any faults in the author of *On The Origin of Species*, or the application of his ideas, cannot be true, its supporters reason.

The fact that Darwin could be described as a "nice person," although with idiosyncrasies, makes his ideas all the more dangerous than if he were a demonstrable psychopath. Yet Darwin was unable to accept a God who allowed injustice. And Bergman's book lays out the data showing Darwin's clear religious motivation, putting it in the starkest terms—to "kill God." Still, there is a great deal of ambivalence in Darwin's writing, best explained as an attempt to avoid offending his cultural peers and his believing wife. Darwin's psychological and psychosomatic illnesses are clearly elucidated, but it is also shown that although this diminished his public defense of his theory, which he left to energetic followers like Huxley, he was able to carry our an extensive correspondence with the aim of making converts.

It is well known that much, if not all, of Darwin's theory was borrowed—even plagiarized—from many who came before him, and he had great trouble in acknowledging this, even when grudgingly forced to do so. But the sloppiness of his scholarship, from failing to label specimens to changing the content of old papers to reflect later thinking, would today be considered worthy of censure.

Also, although unlike his latter-day disciples, he clearly saw the need for an adequate explanation of the variation on which natural selection works, what he leaped to was pangenesis, a form of inheritance of acquired characteristics by the movement of "gemmules" from all parts of the body to the gametes. He had previously rejected this Lamarckian idea, but when no other mechanism was viable, he returned to it and stuck with it despite experimental evidence to the contrary. Darwin's alteration of photographs in a study intended to show the animal origins of facial expression shows a disregard for the facts when a point needs to be proved. In these ways, he served as a role model for all who have followed in his footsteps.

Darwin's clear opinion that some races are inferior and his support of at least "passive" eugenics are clear from what he has written. The typical defense that he opposed slavery is clarified in that he also opposed cruelty to animals, although this was not the case when, as a younger man, he enjoyed killing to a degree far beyond the typical hunter mentality. He was convinced that the higher races would eliminate the lower and even used the word "exterminate," although he shied away from actual killing in favor of preventing reproduction of the less fit. Also, Darwin's documented conviction that women were evolutionarily inferior to men and more like children did not, of course, lead him to the conclusion that they should be eliminated!

To be sure, Darwin's ideas were taken in many directions in which he did not directly participate. But the danger to morality and social stability, not to mention compassion, were probably part of the reason for Darwin's mental distress. The Darwin-Hitler deniers want a smoking gun—a secret conversation that, of course, could not have been possible—and fail to admit that they understand the power of ideas in history. Hitler's programs were completely consistent with Darwin's ideas and just added the political will to stop being passive and get on with it. The fact that racism and sexism predated Darwin does not invalidate the observation that he allowed proponents of those "isms" to become "intellectually fulfilled scientists."

Each book chapter is a unit unto itself with a synopsis at the beginning and conclusions at the end. Because of the format, some anecdotes and quotations are repeated in subsequent chapters. I would have liked to see something about whether Darwin really had access to Mendel's book before publishing his own. An index would have been helpful as well.

This is a valuable book and a reminder of the strong delusion that pervades academia.

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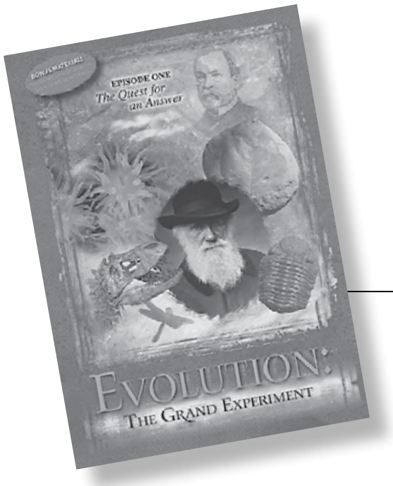

Evolution: The Grand Experiment, Episode Two: Living Fossils (DVD)

by Carl Werner

New Leaf Press, Green Forest, AR, 2011, 53 minutes, $17.00.

This new DVD featuring Dr. Carl Werner packs a robust punch to evolutionary theories about fossils. Dr. Werner is an emergency room physician and in his spare time has spent years searching fossil dig sites and museums and conducting interviews with scientists and curators. His quest? To find out whether or not the fossil record really supports evolution. Specifically, this video documents his search to see whether modern plants and animals are found in the same rock layers as dinosaurs.

Dinosaurs are some of the most popular kinds of extinct animals. Often in museum displays and books featuring dinosaurs, pictures and diagrams show that only certain groups of plants and animals lived during the "Age of Reptiles." This is also known as the Mesozoic Era, when dinosaurs lived on earth (according to evolutionary theory).

Werner hypothesized that if creation is true, then what most paleontologists call "modern" plants and animals (such as flowering plants, mammals, and modern birds) should be found with and beside dinosaur fossils. This would show that no real evolutionary change has occurred. The video traces Werner's travels around the world as he tried to find answers to his question.

This video shows that in fact, many of the types of plants and animals that were once thought to be "modern" (i.e., only alive after the dinosaurs died out) are found with dinosaur fossils. The viewer is taken through invertebrates, reptiles, amphibians, fish, mammals, birds, and plants. The footage throughout the program is very well done and shows spectacular images of many animals and plants, including kangaroos, sea lions, and the Great Barrier Reef. In the video the viewer can visually compare the fossil with modern animals and decide whether they appear to be the same kind of animal. One of the most amazing facts demonstrated is that all of the major kinds of modern animals (or *phyla*) are represented in the dinosaur rock layers, including mammals.

This video is designed to accompany a book by the same name, also by Carl Werner. It is especially valuable for homeschool use, but anyone interested in the evidence for creation and evolution will benefit. The video also functions as an update of Duane Gish's classic *The Fossils Still Say NO!*" (1985), fully agreeing with that book's conclusion. Producer Werner does an excellent job showing that the fossil record is and always has been a friend to the creationist.

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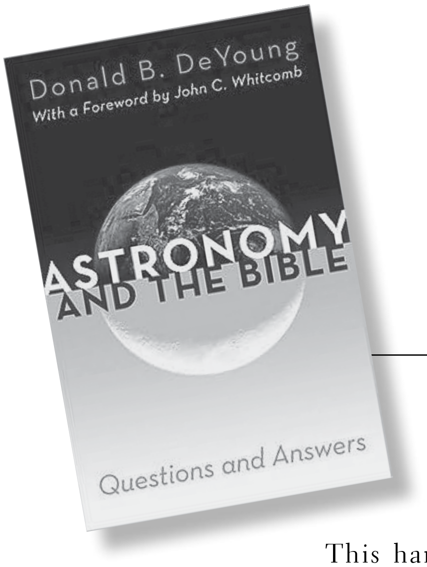

Astronomy and the Bible: Questions and Answers

by Don DeYoung

BMH Books, Winona Lake, IN, 2010, 155 pages, $15.00.

This handy question-and-answer book is a revised and updated version of an earlier work under the same name. It features 100 interesting questions from the world of astronomy, physics, and creation. The book is divided into six chapters that organize the questions into categories including The Earth and the Moon, The Stars, and Technical Terms and Ideas. Every question features informative, helpful, yet short and concise answers that reflect a broad knowledge of the world of science and the message of the Bible.

Some example questions include:

- Do the solar system planets ever line up?
- Is there a time problem with moon dust?
- Which stars are named in Scripture?

An excellent way to enjoy the book is to read one or two questions every day. Seasonal star charts located in the back of the book allow the reader to also enjoy the night sky. All will benefit from reading this book, including homeschoolers, astronomy lovers, and creation enthusiasts. It is written in a way that everyone from children to trained scientists can understand and appreciate. The book contains a glossary of important astronomy terms, observing tips, and indexes for Scripture, names, and subjects.

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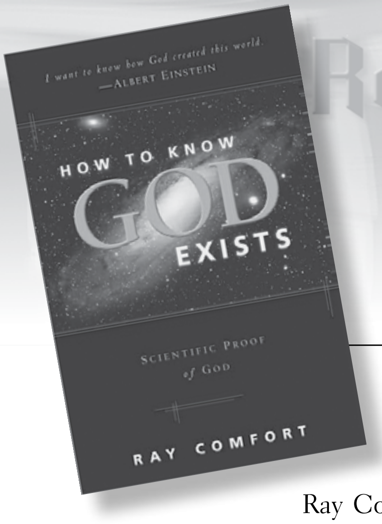
Reviews



How to Know God Exists

by Ray Comfort

Bridge-Logos Publishers,
Alachua, FL, 2007, 192 pages,
$13.00.

Ray Comfort is the author of over 70 books, including several on the creation-evolution debate. This book reveals his interest in apologetics, atheism, and agnosticism. Written for the layman and designed to equip believers with answers raised against Christianity, the book also is a good evangelistic tool. An atheist who reads this book will have a difficult time holding on to his disbelief.

The first two chapters present the commonly cited evidence from design. Comfort discusses some of the "irreducibly complex" arguments that Michael Behe described in his 1996 book *Darwin's Black Box*. The idea expressed is that a building must have a builder; therefore, a creation must have a creator. Comfort concludes the Creator must be the God of the Bible.

The next four chapters continue the discussion, demonstrating evolution's bankruptcy. Comfort draws evidence from a wide selection of scientific fields, including biology, paleontology, and cosmology. Interspersed are many quotes from well-respected scientists, including Isaac Newton and Albert Einstein. Comfort shows the reader that evolutionary theory is incapable of explaining such dilemmas as the origin of life, gaps in the fossil record, and macroevolution.

Perhaps author Comfort's best argument for the existence of God, however, is his discussion of the conscience and morality. If we are simply highly evolved animals, why and how do we know right from wrong? What makes us decide, for example, that murder is wrong? "The problem with atheism," writes Comfort, "is that it has a shifting morality. There are no moral absolutes. How can there be, when [according to atheism] morality is thought to come through human consensus, rather than divine mandate" (p. 87)? If humans are just biological machines composed of random chemicals that formed over millions of years, there is no reason to believe in moral absolutes. As Comfort points out on the same page, this is one of the clearest differences between humans and animals. If humans are just animals that are more highly evolved than the rest, why are we the only species to have a clear sense of justice? Why do we punish wrongdoers? No other animal does anything like this. If someone is wronged, most of us naturally want to make it right.

"We know right from wrong," continues Comfort, "because the conscience is an impartial judge in the courtroom of the mind. It speaks to us irrespective of our will" (p. 87). This is why a lie detector (polygraph) works so well to detect lies. Our conscience tells us lying is wrong and we react physically. For example, a person's blood pressure and heart rate will spike when he lies and the polygraph picks up the changes. If there were no absolutes, the polygraph would not work because we would not have a conscience to tell us when we err.

Further chapters of this book discuss the evidence for authenticity of the Bible, and also address many of the common questions that skeptics raise against Christianity. It provides an easy-to-grasp overview of a topic that can become complicated. In conclusion, this book is a welcome addition to the field of apologetics, especially for the layman. It is a solid place to start for those pursuing the study of apologetics.

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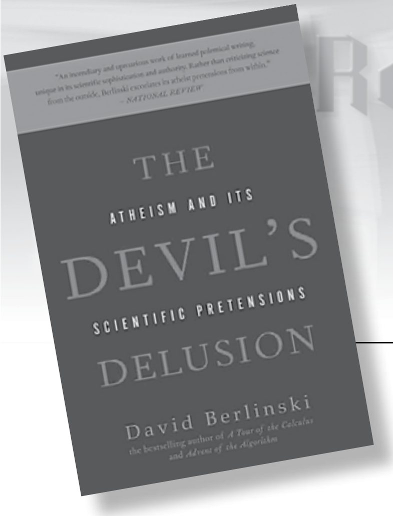
Reviews



The Devil's Delusion

by David Berlinski

Basic Books, New York, 2009,
238 pages, $16.00.

This book is not suitable for speed reading; many sentences deserve a second reading. Berlinski has an impressive command of ancient and modern literature, humor, logic, mathematics, philosophy, science, and vocabulary. You may remember Berlinski's conversation with Ben Stein in the 2008 documentary *Expelled*. Berlinski holds a philosophy Ph.D. from Princeton, has served on the faculty of several universities, and lives in Paris. He is informally connected with Seattle's Discovery Institute.

Berlinski is a frequent contributor to *Commentary* magazine, in which he challenges scientism, or naturalism. He labels himself a secular Jew (p. xiii). At the same time, this book demonstrates a respectful, personal familiarity with the Old and New Testaments, including the Trinity and the incarnation (p. 60). Berlinski wrote this book as an encouragement for people "frustrated by endless scientific boasting. They suspect that as an institution, the scientific community holds them in contempt" (p. xvii).

The author readily takes on and exposes the shallow atheistic arguments of Richard Dawkins, Christopher Hitchens, and others in this sorry band of doubters. Many of Berlinski's phrases and statements are quotable, and a sampling follows.

- Natural selection is described as "the Darwinian business of scrabbling up the greasy pole of life" (p. 17).
- Regarding the science establishment, "the worldwide fraternity of academics who are professionally occupied in sniffing the underwear of their colleagues for signs of ideological deviance" (p. 52).
- Concerning Stephen Hawking's 1988 *A Brief History of Time*: "Widely considered fascinating by those who did not read it, and incomprehensible to those who did" (p. 98).
- Concerning the popularity of the multi-universe idea: "It is better to have many worlds than one God" (p. 135).
- Concerning evolutionary details: "If they are no good, why champion them? And they are no good. So why champion them?" (p. 165).
- An understatement concerning the comparable mysteries of the particle-wave nature of light and the Trinitarian nature of the Deity: "This is not an analogy that has captured the allegiance of scientific atheists" (p. 93).
- "A miracle is what it seems: an event offering access to the divine" (p. 182).
- "Computer simulations of Darwinian evolution fail when they are honest and succeed only when they are not" (p. 190).
- "Although Darwin's theory is very often [said to be] as well established as gravity, very few physicists have been heard observing that gravity is as well established as evolution. They know better and they are not stupid" (p. 191).
- If God directly addressed scientists, He might say, "You have *no* idea whatsoever how the ordered physical, moral, mental, aesthetic, and social world in which you live could have ever arisen from the seething anarchy of elementary particles" (p. 201).

At the end of the book Berlinski presents an interesting reversal of Galileo's geocentric-heliocentric controversy. He suggests that evolutionary science itself has become an unwieldy, outdated religion complete with an ecclesiastical hierarchy, museum edifices, Darwinian holy books, and extreme efforts to convert doubters. Supporters of this secular worldview are thus in a similar position to the geocentrists of the 1600s, including inner doubts that cannot be expressed in public.

Berlinski may be an agnostic as Wikipedia claims; however, his sharp pen pierces the armor of all who promote militant atheism. The book's subtitle is *Atheism and its Scientific Pretensions*. One shortcoming of the writing is the frequent use of quotes without documentation. One gets the feeling that Berlinski has the time, place, and context of these quotations memorized.

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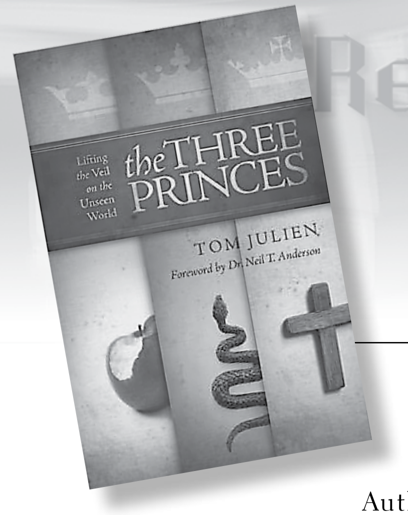
Lifting the Veil on the Unseen World
the THREE PRINCES
TOM JULIEN
Foreword by Dr. Neil T. Anderson

Reviews

The Three Princes

by Tom Julien

Brethren Missionary Herald
Books, Winona Lake, IN,
190 pages, $17.00.

Author Tom Julien and his wife Doris served 28 years as missionaries in France. Tom's distinguished career includes establishing a strategic French conference center for evangelism, training, and church planting. He also has written several theological books and directed Grace Brethren International Missions.

The three princes in the book's title refer to Adam, Lucifer, and the Lord Jesus. "Throughout history, three princes have exercised authority over the earth" (Back cover). Author Julien summarizes the pitifully short reign of sinless mankind, the dark strategies of Satan since the Fall, and the Lord's total victory over evil forces. Why is this book reviewed in the Quarterly? The reason is because Tom Julien is a strong six-day creationist and gives keen insights on many related issues.

A gracious refutation of the gap theory appears on page 19. Regarding angels, the book discusses their creation and the time of the fall of one third of the angelic realm (Rev. 12:4, 9). The devil and his host are described correctly as neither omniscient, omnipresent, nor omnipotent (pp. 5, 96). The case is made that Satan was taken by complete surprise at the Creator's humble birth in Bethlehem two millennia ago: "Tension in the unseen world soared when news began to circulate that a mysterious event had occurred … We can only imagine the intense struggles between the angels and the demonic forces focused on this tiny baby. … Satan was thoroughly perplexed by this Jesus of Nazareth" (pp. 45, 47, 62). The three heavens of 2 Corinthians 12:2 are described as the total physical cosmos, the spirit world, and the dwelling place of God (p. 171). A strong case is made that in all the cosmos, planet earth is the center of God's attention (p. 173).

The book gives major emphasis to the good and evil forces of the spirit world. While serving on the mission field in France, the Juliens saw many examples of demonic oppression. Certain parts of France and elsewhere appear to be strongholds of spiritual darkness (p. 90). It is well to remember that the creation-evolution controversy has an unseen dimension with spiritual conflicts raging. At the same time, this book reminds readers that good will prevail: "We who are in 'Christ' outrank Satan and all his angels" (p. 84). The battle against the forces of evil is already won. This clearly written paperback includes a Scripture index and a foreword by writer Neil Anderson.

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Instructions to Authors

Submission

Electronic submissions of all manuscripts and graphics are preferred and should be sent to the editor of the *Creation Research Society Quarterly* in Word, WordPerfect, or Star-Office/Open Office (see the inside front cover for address). Printed copies also are accepted. If submitting a printed copy, an original plus two copies of each manuscript should be sent to the editor. The manuscript and copies will not be returned to authors unless a stamped, self-addressed envelope accompanies submission. If submitting a manuscript electronically, a printed copy is not necessary unless specifically requested by the *Quarterly* editor. Manuscripts containing more than 35 pages (double-spaced and including references, tables, and figure legends) are discouraged. An author who determines that the topic cannot be adequately covered within this number of pages is encouraged to submit separate papers that can be serialized.

All submitted manuscripts will be reviewed by two or more technical referees. However, each section editor of the *Quarterly* has final authority regarding the acceptance of a manuscript for publication. While some manuscripts may be accepted with little or no modification, typically editors will seek specific revisions of the manuscript before acceptance. Authors will then be asked to submit revisions based upon comments made by the referees. In these instances, authors are encouraged to submit a detailed letter explaining changes made in the revision, and, if necessary, give reasons for not incorporating specific changes suggested by the editor or reviewer. If an author believes the rejection of a manuscript was not justified, an appeal may be made to the *Quarterly* editor (details of appeal process at the Society's web site, www.creationresearch.org).

Authors who are unsure of proper English usage should have their manuscripts checked by someone proficient in the English language. Also, authors should endeavor to make certain the manuscript (particularly the references) conforms to the style and format of the *Quarterly*. Manuscripts may be rejected on the basis of poor English or lack of conformity to the proper format.

The *Quarterly* is a journal of original writings, and only under unusual circumstances will previously published material be reprinted. Questions regarding this should be submitted to the Editor (CRSQeditor@creationresearch.org) prior to submitting any previously published material. In addition, manuscripts submitted to the *Quarterly* should not be concurrently submitted to another journal. Violation of this will result in immediate rejection of the submitted manuscript. Also, if an author uses copyrighted photographs or other material, a release from the copyright holder should be submitted.

Appearance

Manuscripts shall be computer-printed or neatly typed. Lines should be double-spaced, including figure legends, table footnotes, and references. All pages should be sequentially numbered. Upon acceptance of the manuscript for publication, an electronic version is requested (Word, WordPerfect, or Star-Office/Open Office), with the graphics in separate electronic files. However, if submission of an electronic final version is not possible for the author, then a cleanly printed or typed copy is acceptable.

Submitted manuscripts should have the following organizational format:

1. Title page. This page should contain the title of the manuscript, the author's name, and all relevant contact information (including mailing address, telephone number, fax number, and e-mail address). If the manuscript is submitted by multiple authors, one author should serve as the corresponding author, and this should be noted on the title page.

2. Abstract page. This is page 1 of the manuscript, and should contain the article title at the top, followed by the abstract for the article. Abstracts should be between 100 and 250 words in length and present an overview of the material discussed in the article, including all major conclusions. Use of abbreviations and references in the abstract should be avoided. This page should also contain at least five key words appropriate for identifying this article via a computer search.

3. Introduction. The introduction should provide sufficient background information to allow the reader to understand the relevance and significance of the article for creation science.

4. Body of the text. Two types of headings are typically used by the *CRSQ*. A major heading consists of a large font bold print that is centered in column, and is used for each major change of focus or topic. A minor heading consists of a regular font bold print that is flush to the left margin, and is used following a major heading and helps to organize points within each major topic. Do not split words with hyphens, or use all capital letters for any words. Also, do not use bold type, except for headings (italics can be occasionally used to draw distinction to specific words). Italics should not be used for foreign words in common usage, e.g., "et al.", "ibid.", "ca." and "ad infinitum." Previously published literature should be cited using the author's last name(s) and the year of publication (ex. Smith, 2003; Smith and Jones, 2003). If the citation has more than two authors, only the first author's name should appear (ex. Smith et al., 2003). Contributing authors should examine this issue of the *CRSQ* or consult the Society's web site for specific examples as well as a more detailed explanation of manuscript preparation. Frequently-used terms can be abbreviated by placing abbreviations in parentheses following the first usage of the term in the text, for example, polyacrylamide gel electrophoresis (PAGE) or catastrophic plate tectonics (CPT). Only the abbreviation need be used afterward. If numerous abbreviations are used, authors should consider providing a list of abbreviations. Also, because of the variable usage of the terms "microevolution" and "macroevolution," authors should clearly define how they are specifically using these terms. Use of the term "creationism" should be avoided. All figures and tables should be cited in the body of the text, and be numbered in the sequential order that they appear in the text (figures and tables are numbered separately with Arabic and Roman numerals, respectively).

5. Summary. A summary paragraph(s) is often useful for readers. The summary should provide the reader an overview of the material just presented, and often helps the reader to summarize the salient points and conclusions the author has made throughout the text.

6. References. Authors should take extra measures to be certain that all references cited within the text are documented in the reference section. These references should be formatted in the current *CRSQ* style. (When the *Quarterly* appears in the references multiple times, then an abbreviation to *CRSQ* is acceptable.) The examples below cover the most common types of references:

Robinson, D.A., and D.P. Cavanaugh. 1998. A quantitative approach to baraminology with examples from the catarrhine primates. *CRSQ* 34:196–208.

Lipman, E.A., B. Schuler, O. Bakajin, and W.A. Eaton. 2003. Single-molecule measurement of protein folding kinetics. *Science* 301:1233–1235.

Margulis, L. 1971a. The origin of plant and animal cells. *American Scientific* 59:230–235.

Margulis, L. 1971b. *Origin of Eukaryotic Cells*. Yale University Press, New Haven, CT.

Hitchcock, A.S. 1971. *Manual of Grasses of the United States*. Dover Publications, New York, NY.

Walker, T.B. 1994. A biblical geologic model. In Walsh, R.E. (editor), *Proceedings of the Third International Conference on Creationism* (technical symposium sessions), pp. 581–592. Creation Science Fellowship, Pittsburgh, PA.

7. Tables. All tables cited in the text should be individually placed in numerical order following the reference section, and not embedded in the text. Each table should have a header statement that serves as a title for that table (see a current issue of the *Quarterly* for specific examples). Use tabs, rather than multiple spaces, in aligning columns within a table. Tables should be composed with *14-point type* to insure proper appearance in the columns of the *CRSQ*.

8. Figures. All figures cited in the text should be individually placed in numerical order, and placed after the tables. Do not embed figures in the text. Each figure should contain a legend that provides sufficient description to enable the reader to understand the basic concepts of the figure without needing to refer to the text. Legends should be on a separate page from the figure. All figures and drawings should be of high quality (hand-drawn illustrations and lettering should be professionally done). Images are to be a minimum resolution of 300 dpi at 100% size. Patterns, not shading, should be used to distinguish areas within graphs or other figures. Unacceptable illustrations will result in rejection of the manuscript. Authors are also strongly encouraged to submit an electronic version (.cdr, .cpt, .gif, .jpg, and .tif formats) of all figures in individual files that are separate from the electronic file containing the text and tables.

Special Sections

Letters to the Editor:

Submission of letters regarding topics relevant to the Society or creation science is encouraged. Submission of letters commenting upon articles published in the *Quarterly* will be published two issues after the article's original publication date. Authors will be given an opportunity for a concurrent response. No further letters referring to a specific *Quarterly* article will be published. Following this period, individuals who desire to write additional responses/comments (particularly critical comments) regarding a specific *Quarterly* article are encouraged to submit their own articles to the *Quarterly* for review and publication.

Editor's Forum:

Occasionally, the editor will invite individuals to submit differing opinions on specific topics relevant to the *Quarterly*. Each author will have opportunity to present a position paper (2000 words), and one response (1000 words) to the differing position paper. In all matters, the editor will have final and complete editorial control. Topics for these forums will be solely at the editor's discretion, but suggestions of topics are welcome.

Book Reviews:

All book reviews should be submitted to the book review editor, who will determine the acceptability of each submitted review. Book reviews should be limited to 1000 words. Following the style of reviews printed in this issue, all book reviews should contain the following information: book title, author, publisher, publication date, number of pages, and retail cost. Reviews should endeavor to present the salient points of the book that are relevant to the issues of creation/evolution. Typically, such points are accompanied by the reviewer's analysis of the book's content, clarity, and relevance to the creation issue.

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Please complete the lower portion of this form and mail it with payment to CRS Membership Secretary, P.O. Box 8263, St. Joseph, MO 64508-8263, or fax for credit card payment to (816) 279-2312. Applications may also be completed online at creationresearch.org.

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Creation Research Society

History—The Creation Research Society was organized in 1963, with Dr. Walter E. Lammerts as first president and editor of a quarterly publication. Initially started as an informal committee of 10 scientists, it has grown rapidly, evidently filling a need for an association devoted to research and publication in the field of scientific creation, with a current membership of over 600 voting members (graduate degrees in science) and about 1000 non-voting members. The *Creation Research Society Quarterly* is a peer-reviewed technical journal. It has been gradually enlarged and modified, and is currently recognized as one of the outstanding publications in the field. In 1996 the *CRSQ* was joined by the newsletter *Creation Matters* as a source of information of interest to creationists.

Activities—The Society is a research and publication society, and also engages in various meetings and promotional activities. There is no affiliation with any other scientific or religious organizations. Its members conduct research on problems related to its purposes, and a research fund and research center are maintained to assist in such projects. Contributions to the research fund for these purposes are tax deductible. As part of its vigorous research and field study programs, the Society operates The Van Andel Creation Research Center in Chino Valley, Arizona.

Membership—Voting membership is limited to scientists who have at least an earned graduate degree in a natural or applied science and subscribe to the Statement of Belief. Sustaining membership is available for those who do not meet the academic criterion for voting membership, but do subscribe to the Statement of Belief.

Statement of Belief—Members of the Creation Research Society, which include research scientists representing various fields of scientific inquiry, are committed to full belief in the biblical record of creation and early history, and thus to a concept of dynamic special creation (as opposed to evolution) both of the universe and the earth with its complexity of living forms. We propose to re-evaluate science from this viewpoint, and since 1964 have published a quarterly of research articles in this field. *All members of the Society subscribe to the following statement of belief*:

1. The Bible is the written Word of God, and because it is inspired throughout, all its assertions are historically and scientifically true in all the original autographs. To the student of nature this means that the account of origins in Genesis is a factual presentation of simple historical truths.
2. All basic types of living things, including humans, were made by direct creative acts of God during the Creation Week described in Genesis. Whatever biological changes have occurred since Creation Week have accomplished only changes within the original created kinds.
3. The Great Flood described in Genesis, commonly referred to as the Noachian Flood, was a historical event worldwide in its extent and effect.
4. We are an organization of Christian men and women of science who accept Jesus Christ as our Lord and Savior. The act of the special creation of Adam and Eve as one man and woman and their subsequent fall into sin is the basis for our belief in the necessity of a Savior for all people. Therefore, salvation can come only through accepting Jesus Christ as our Savior.